Water

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GROUNDWATER RESOURCES EVALUATION

CORNWALL

THE CANADA – PRINCE EDWARD ISLAND
WATER MANAGEMENT AGREEMENT

Environment Canada Environnement Canada

Prince Edward Island
Department of the Environment

GROUNDWATER RESOURCES EVALUATION

CORNWALL

92-07519/

Groundwater Resources Evaluation - Cornwall

Executive Summary

A test drilling program and review of the available hydrogeological data for the Community of Cornwall was conducted during 1989 to document the status of groundwater resources in the community. The results of this investigation indicate that natural water quality in the area is generally good, although the aquifer is relatively vulnerable to contamination due to the presence of relatively thin, permeable overburden. Principle water quality concerns relate to bacterial contamination resulting both from sewer line breaks and natural soil conditions and incidences of groundwater contamination by petroleum products from leaking petroleum storage tanks. The servicing of the community with central water, with supply coming form "protected " well fields, should reduce or eliminate these problems.

Test drilling and existing hydrogeological data suggest that there is good potential for the development of high capacity wells in much of the area, although well yields at a test site in the north west portion of the community were disappointing. There may be a north-easterly trending zone of higher yields in the vicinity of Hyde Creek. A key factor in locating potential well fields will be the availability of a suitable land base for which adequate well field protection measures can be adopted, and which are have not already experienced a significant degradation of water quality due to previous incidences of contamination. Regrettably, test well COR-3, which appears capable of very good yields, is located in an area which is both prone to contamination and where effective well field protection measures would be difficult to implement. Test drilling immediately to the east of this site, across Hyde Creek could identify similar potential for the development of high capacity wells in an area more easily protected.

The implementation of some form of land use restrictions in areas with potential for water supply development would help ensure that options for future supply remain open. A heightened awareness of water quality issues will be important components of the wise management of the communities' groundwater resources.

Acknowledgments

This study was completed as a part of the Canada - P.E.I. Water Management Agreement, a joint initiative of Environment Canada and the Prince Edward Island Department of the Environment. The author wishes to acknowledge the efforts of Don Carey of Jaques, Whitford and Associates, who oversaw the compilation of much of the information upon which this study was based. Thanks go also to the many staff of the P.E.I. Department of the Environment for the many stimulating and fruitful discussions on various aspects of this work. Particular gratitude is expressed to Paul Baker for his able support in various office and field activities during the preparation of this work. The patient review of this manuscript, and guidance through various phases of this work by Rory Francis, P.E.I. Department of the Environment and John Gibb, Environment Canada is gratefully appreciated.

Groundwater Resource Evaluation
Community of Cornwall

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Cornwall

1.0 Introduction

This report documents the findings of a study of the groundwater resources of the Community of Cornwall, conducted as a part of the the Groundwater Resources Evaluation Project under the Canada - P.E.I. Water Management Agreement. The purpose of this project is to investigate, through a series of studies, the available groundwater resources in selected communities across the Island and to make recommendations regarding the most appropriate manner of developing and protecting this resource, in light of the physical constraints and expected water needs of each community.

In this study, data collected through test drilling and field reconnaissance, augmented by existing data for the Community of Cornwall is assessed, and conclusions drawn regarding the availability and quality of groundwater resources in the study area, and the most appropriate manner of developing and protecting this resource.

2. Geography

2.1 Physical Geography

The Community of Cornwall is located in the central portion of Prince Edward Island, just west of Charlottetown. Surface relief is rolling, with slopes in the community generally towards Hyde Creek, which forms most of the eastern boundary of the community. The community covers an area of 180 ha, with the community centre around the intersection of the Trans-Canada Highway, Ferry Road, Cornwall Road, and Meadowbank Road. The highest ground is located along the western boundary of the community at 37 m, and low lying, swampy and saltmarsh areas occur along Hyde Creek at or near sea level.

2.2 Cultural Geography

The Community of Cornwall is primarily a residential area, with a number of retail and service businesses, motels, schools, service stations etc. Commercial activities are concentrated along the Trans Canada highway . There is some agricultural land within the community. The population according to the 1986 census was 1894. In a study conducted for the Cornwall Planning Board in 1984, it was projected that the community would continue to grow, reaching a population of 2700 by the year 2000, with a maximum population within the existing community boundaries of 2860 by the year 2005.

3. Geology

3.1 Surficial Geology

Overburden in the Cornwall area is varied. Along Hyde Creek, glaciofluvial kame terrace deposits are found, consisting of well to poorly stratified sand, gravel and boulders. Bordering the terrace deposits, are loose stoney to bouldery sand ablation moraine deposits. The remaining areas are underlain by clay phase ground moraine deposits (Prest, 1973). From well drillers reports, overburden thickness averages 5.9 meters.

The soil survey report (MacDougall & Veer, 1981) indicates soils in this area are predominantly Charlottetown series, described as moderately coarse textured, strongly acidic ground moraine, with well drained surfaces and moderate to slow sub surface permeability (less than 1 x 10 -4 cm/sec.), and deep water tables. Along the creek, the Charlottetown series (70%) is joined by 20% Malpeque series soils which are moderately coarse textured , acid ground moraine on gently undulating relief with imperfect surface drainage, slow subsoil permeability and seasonally high water tables.

3.2 Bedrock Geology

Bedrock consists of Lower Permian sedimentary strata of Mega cyclic Sequence III (Van de Poll, 1981) which together with the other three megacyclic sequences identified on Prince Edward Island are believed to be slightly younger stratigraphic equivalents of the strata comprising the upper portions of the Pictou Group found elsewhere in the Maritime Provinces. These units consist of red conglomerate, sandstone and siltstone, generally becoming coarser with depth, with the basal conglomerate overlying the sandstone and siltstone of Megacyclic Sequence II. Well drillers reports indicate that wells in the area penetrate predominantly sandstone and claystone, with some siltstone.

The environment of deposition of these sedimentary strata is considered to be fluvial in origin , and the stratigraphy is characterized by rapid lateral facies changes, representing recurring fluvial cycles.

Lithological and geophysical logs of test holes drilled under this program (see Figure 2) indicate that bedrock is composed of predominantly sandstone sequences, interbedded with varying amounts of siltstone and claystone. While massive sandstone units of up to 8m in thickness occur at each site, the majority of the strata are composed of more finely interbedded sandstone, siltstone and claystone sequences. While the stratigraphy at each site is grossly similar, there is a higher proportion of thinly bedded, finer grained sediments at site 1.

Interbedded sandstone , siltstone and claystone sequences are generally composed of very fine to medium grained sandstones alternating with varying amounts to red brown soft siltstone to silty claystone, and green-grey hard siltstone to very fine grained sandstone. While the nature

of the drill cuttings make it difficult to determine with certainty, these sediments appear to be relatively thinly bedded and the more finely textured sediments occasionally exhibit a weak bedding plane fissility.

Massive sandstone units are generally composed of reddish brown, fine to medium grained arkosic, occasionally somewhat micaceous sandstone with a cement composed primarily of hematite mud, and more rarely conspicuous amounts of carbonate minerals. At site 2, progressive fining upward trends are well developed throughout much of the test hole, while at site one this feature is usually absent or poorly developed. Rarer coarsening up trends are seen in each section, again being better developed at site 2.

Discrete claystone units are less common than massive sandstone beds and are rarely more than a metre in thickness. These discrete claystone layers are generally composed of soft, pliable, red brown clay with no observable internal structure visible in the drill cuttings.

4. Hydrogeology

4.1 Existing Well Data

The P.E.I. Department of the Environment has approximately 270 well drillers reports for wells drilled in the Community of Cornwall between 1970 and 1987. Well depths average 31 m with a maximum depth of 79 m and a minimum depth of 16 m. The majority of wells are generally less than 43 m in depth . Only four wells in the community have a depth of greater than 76 m and two of these wells were drilled as a part of this program.

Casing lengths average 13 m ranging from 6 m to over 30 m. The average well yield as reported on the well drillers reports is 0.91 litres per second (L/sec.) and ranges widely from a minimum of 0.38 L/sec. to a maximum of 5.68 L/sec. It should be noted however that most of the well yields recorded on the well drillers reports have been determined by relatively short (10 to 15 minute) bail tests which have limited accuracy, thus caution should be used in interpreting this data. One well drilled as part of this program was pumped at a rate of 21 L/sec. without an excessive amount of drawdown.

To make more meaningful the well yield data from the well drillers reports, the well depth , or more precisely the saturated portion of the aquifer penetrated by the well should be taken into account when comparing well yields.

As is common on P.E.I., individual aquifers are difficult to identify, especially as the flow of water through fractures is probably more significant than primary porosity in determining hydraulic conductivity (Francis 1981). For these reasons the entire saturated thickness of sediments penetrated by a well can be approximated as a single semi- confined aquifer.

As a measure of aquifer yield then, the yield per metre of saturated aquifer thickness (Y/S.T. in litres per second per metre (L/sec/m) for each well has been calculated. The average yield per metre of saturated thickness is 0.037 L/sec/m. This would suggest for example, that on average a well 60 m deep, with a water level of 12 m below ground level should be capable of yielding approximately 0.68 L/sec.

In reality of course, some wells will have much higher yields per foot of saturated thickness, while others will have less. The highest value indicated by the available data was a yield per metre of saturated thickness of 0.42 L/sec/m of saturated thickness and few wells had yields of less than 0.0023 L/sec/m.

A cursory review of the well yield data suggests that many of the higher yielding wells occur in an area running approximately north-south in the eastern end of the community. While there is no direct evidence of any lithological or structural feature to explain this apparent trend, it may represent a zone of greater fracture frequency possibly related to larger scale geological control.

Static water levels in the community as indicated on the well drillers reports average 11.6 metres below ground level with a reported range of 3 m to 27 m. This is a surprising range of water levels for a relatively small area, and probably reflect the fact that water level measurements have been made at a number of different times during the year(ie at the time of drilling), thus incorporating seasonal variations in the water table as well as variations from location to location. There are no continuously monitored wells in the community however, extrapolation from hydrographs from monitoring wells at the Charlottetown airport and New Dominion suggests that water levels in a single well could exhibit a range in the order of 6 m in any given year.

4.2 Test Drilling Program

To evaluate the aquifer characteristics in the area, test drilling was conducted at two sites in the community, with a total of three wells drilled, logged and pump tested.

4.2.1 Site election

The first site (site #1 on Figure 1) was chosen primarily because of its suitability as an area for potential development of comprehensive well field protective measures. Topographic considerations as well as current iand use practices and development density provide for a site which should be relatively free from contamination and where protective measures such as appropriate land use zoning could be readily adopted.

Prior to drilling, no estimate of probable well yields was possible, due to a lack of information for the area, although the presence of an intermittent stream in the area contributed to hopes that reasonable well yields would be found. Subsequent test drilling and pump testing showed that this was not the case.

Site #2 was selected as an alternate site for test drilling and was selected primarily on the basis of expected high well yields, in spite of the fact that the site is not as suitable from a well field protection perspective as site #1.

4.2.2 Test Drilling and Pump testing

Test Drilling

Test drilling at site 1 consisted of the construction of two test holes approximately 60 metres apart, along the northern margin of agricultural lands. Each well is 20 cm in diameter and 76 m deep. Bedrock was encountered in test hole COR-1 at a depth of 7.2 m, and water was first encountered in the interval of 9 - m. Bedrock was encountered at a depth of approximately 4.8 m in test hole COR-2. Both wells are cased to a depth of 12 m with the casing grouted with bentonite. At completion of drilling, static water levels were 9.6 m and 12.5 m for test hole COR-1 & COR-2 respectively. A lithological and gamma log of test hole COR-2 is presented in Figure 2.

At site #2, a single 20 cm well (test hole COR-3) was drilled to a depth of 60 m, in an effort to identify an area of potentially higher well yield. Bedrock was encountered at a depth of approximately 6 m. As for test holes COR-1 & COR-2 the well was cased to a depth of 12 m and the annular space sealed with bentonite. The static water level for this well was 6.7 m at the time of completion. A lithological and gamma log of Test hole COR-3 is presented on Figure 2 .

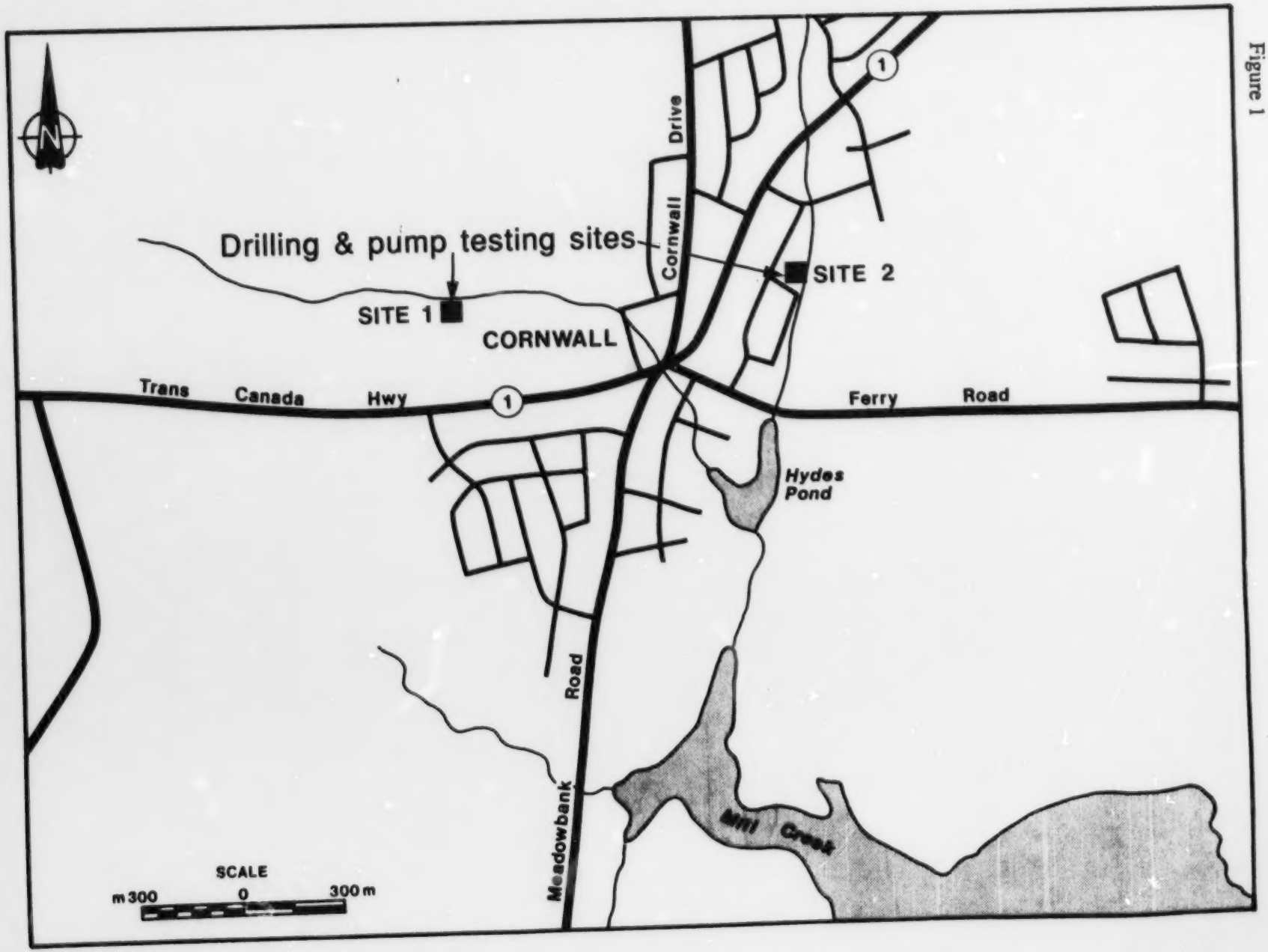
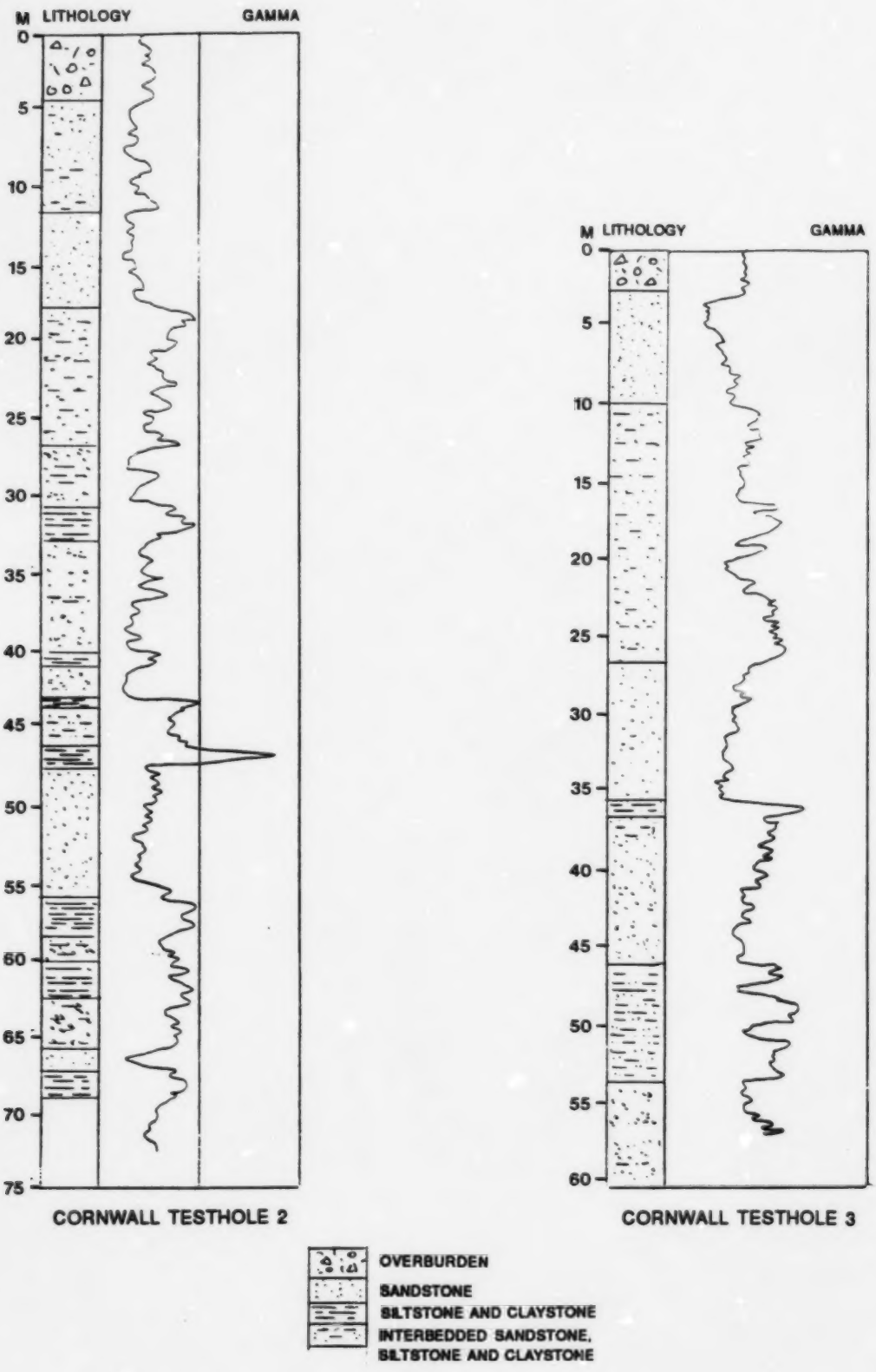

N
Drilling & pump testing sites
SITE 1
SITE 2
CORNWALL
Cornwall Drive
1
Trans Canada Hwy
1
Ferry Road
Hydes Pond
Meadowbank Road
Mill Creek
SCALE
m 300 0 300 m

Figure 1

Figure 2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CORNWALL TESTHOLE 2
M
LITHOLOGY
GAMMA
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5
10
15
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35
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45
50
55
60
CORNWALL TESTHOLE 3
OVERBURDEN
SANDSTONE
SILTSTONE AND CLAYSTONE
INTERBEDDED SANDSTONE, SILTSTONE AND CLAYSTONE

Pump Testing

At site #1 test holes COR-1 and Cor-2 were each subjected to step drawdown pump tests. Well yields in each case were very modest, and it is unlikely that more than approximately 3 L/sec. could be pumped from either well for extended periods of time. Because of the disappointing yields from these wells , no constant rate test was performed to further evaluate well performance or aquifer conditions.

Pump test data from step drawdown tests for each well are summarized in Table 1. In the table, values for discharge rate Q (in L/sec.) drawdown (m), and specific capacity (S.C.) are listed. Specific capacity is a measure of the amount drawdown in the well for a given pumping rate and duration of pumping, and can be used to help assess an appropriate pumping rate for the well. Specific capacity here is measured in litres per second (L/sec.) pumped per metre of drawdown in the well (L/sec/m).

Figures 3 and 4 show graphically the results of the step drawdown tests as well as the theoretical drawdown expected for different pumping rates according to the relationship $s = BQ + CQ^2$ where s is drawdown, Q is the discharge rate and B and C are coefficients derived form the test data that represent components of drawdown related to laminar and turbulent flow respectively. Because the relationship this curve is based on is only approximate, these curves should be interperated with caution. In particular, any extrapolations made beyond the maximum pumping rate for the test is likely to underestimate the amount of drawdown.

Table 1

test hole 1			test hole 2		
Q (L/sec)	Drawdown (m)	S.C. (L/sec/m)	Q (L/sec)	Drawdown (m)	S.C. (L/sec/m)
1.5	3.62	0.038	1.5	6.29	0.22
2.8	11.09	0.023	2.7	12.34	0.019
3.8	40.16	0.009	3.8	22.46	0.016

In each case the wells were pumped for three consecutive 30 minute periods at different pumping rates. The results indicate a relatively sharp decline in S.C. above pumping rates of 2.7 - 3 L/sec. This may represent a rapid increase in the proportion of total head losses attributable to turbulent flow (commonly referred to as "well losses" at these rates.

A constant rate test was not performed at this site due to the relatively low yields of these wells, rather it was felt that the available resources would be better employed in seeking an area with higher potential well yields. To properly assess the long term potential yields of

Figure 3

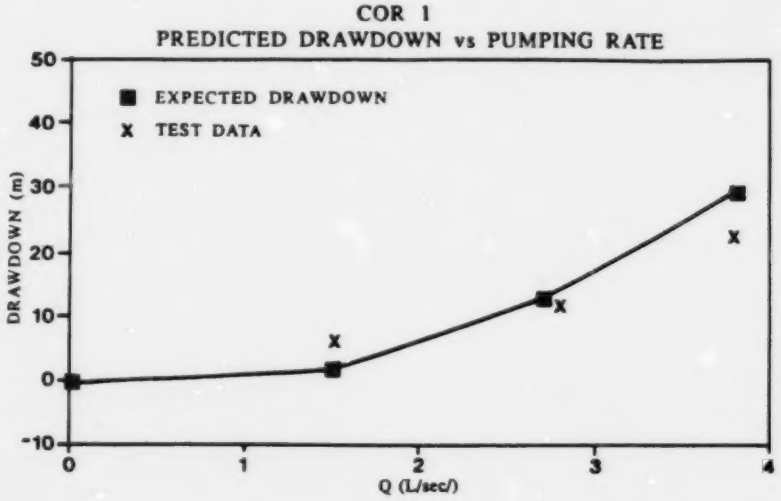


Figure 4

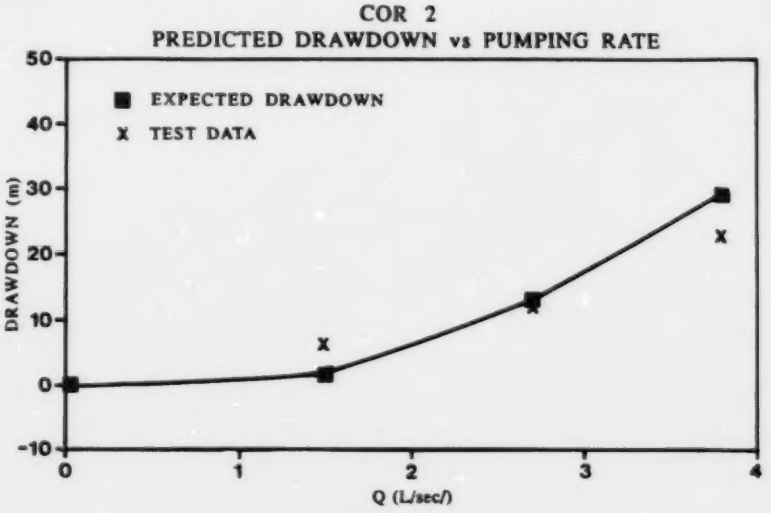
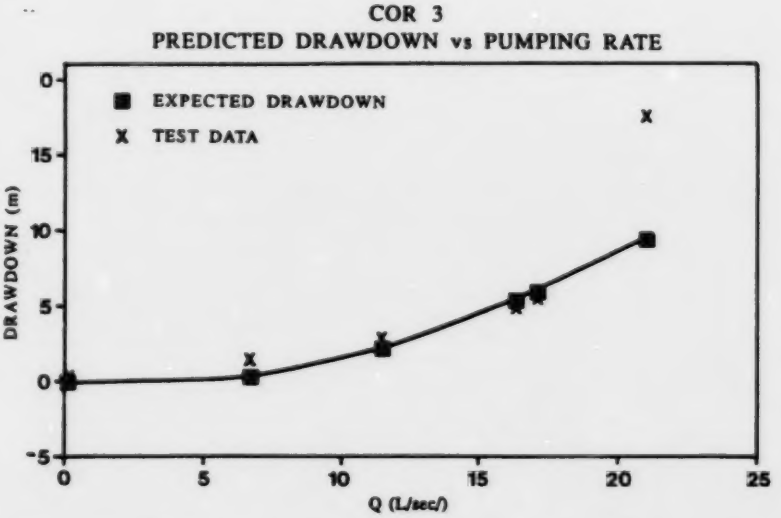


Figure 5



these wells, and further testing would be required. In spite of the lack of a constant rate pump test on these wells, it can be suggested that the transmissibility of the aquifer in the immediate proximity of these wells may be as low as 15 m^2/day, based on the drawdown and recovery measurements made during the step drawdown tests .

Water samples collected from each well at the conclusion of the pump testing indicates that the water is of calcium bicarbonate type, and is moderately soft to hard. In each case the water is acceptable for drinking, based on Canadian Drinking Water Guidelines.

At site #2, test hole COR-3 was subjected to a step drawdown pump test and a short constant rate test. No observation well was constructed to monitor constant rate pump test results, and access could not be gained to any suitable nearby wells for this purpose. The results from this well were far more promising than for those from site #1, and the well appears to be capable of yielding substantial volumes of water. Results of the step drawdown test are summarized below in Table 2, and shown graphically on Figure 5 in the same manner as for COR-1 and 2.

Table 2

Q (L/sec)	Drawdown (m)	S.C. (L/sec/m)
6.6	1.33	0.46
11.4	2.76	0.38
16.3	4.86	0.31
17.0	5.46	0.29
20.9	17.37	0.11

The results of this step drawdown test suggest that test well COR-3 is capable of supplying at least 19 L/sec, and possibly more, depending on the allowable drawdown assigned to the well. In addition to the step drawdown test a short constant rate test was conducted on for a period of 12 hours to further asses the performance of the well and to get a rough indication of some aquifer characteristics.

The results of the test indicate a transmissibility of approximately 745 m^2/day. No observation well was available for this test and thus no estimate of the storativity of the aquifer in this vicinity can be made. The results do indicate that while the drawdown effects from pumping this well would be expected to be quite limited in depth although quite wide spread in lateral extent.

4.3 Groundwater flow regime

While there are abundant well data available for the community of Cornwall, it is difficult to establish an accurate picture of the groundwater flow regime in the area. None the less it is possible to construct an idealized view of the groundwater flow regime, which although not accurate in detail, does provide an indication of groundwater flow directions and gradients.

The most serious difficulty with the data is the fact that static water level measurements have been made during different times of the year (ie, at the time the well was constructed), and as noted previously, the static water level could vary by as much as 6 m for a given well in any given year. Fortunately it could be expected that the highest portion of these wells would have been drilled during the summer months when the construction season is at its peak, thus temporal variations in water levels may be reduced somewhat.

A second concern of lesser importance, is that most of the wells for which data are available are of a similar depth (average of 30 m). Thus the conclusions drawn here are applicable primarily to the depths that the average domestic wells are drilled, and not to deeper portions of the groundwater flow regime. These conditions could possibly be extrapolated to slightly greater depths, including depths relevant to the construction of production wells which might supply a central water supply system.

At the other end of the scale, this well data does not include information on the shallowest portions of the flow regime either , and probably do not accurately describe the interaction of the surface water and groundwater regimes in the near surface environment. This limitation is probably of little practical significance, except perhaps in cases where information on highly localized shallow flow is sought.

Figure 6 shows a highly idealized picture of the groundwater flow regime. Generally the groundwater flow regime in the Cornwall area forms a symmetrical pattern converging from the east, north and west towards Hyde Creek, and as might be expected, is a subdued reflection of the local topography. Thus for instance, in areas of higher relief, where the topographic gradient is relatively steep, the hydraulic gradient is also steep relative to areas of lower relief, although not as steep as the topographic gradient.

On Figure 6, the topographic gradient is approximately 3% along the line A - A', while the horizontal component of the hydraulic gradient is approximately 1.6%. In contrast, in areas of lower relief, such as along line B - B', the topographic gradient and the hydraulic gradient are both shallower and more similar with slopes of 1.2% and 1% respectively.

It is likely that Hyde Creek itself is an effective natural boundary, separating the eastern and western portions of the flow system, at least to depths represented by the existing well data. This feature could have implications for the siting of potential production wells, particularly if a site was chosen which could take advantage of this natural boundary to isolate the wells from

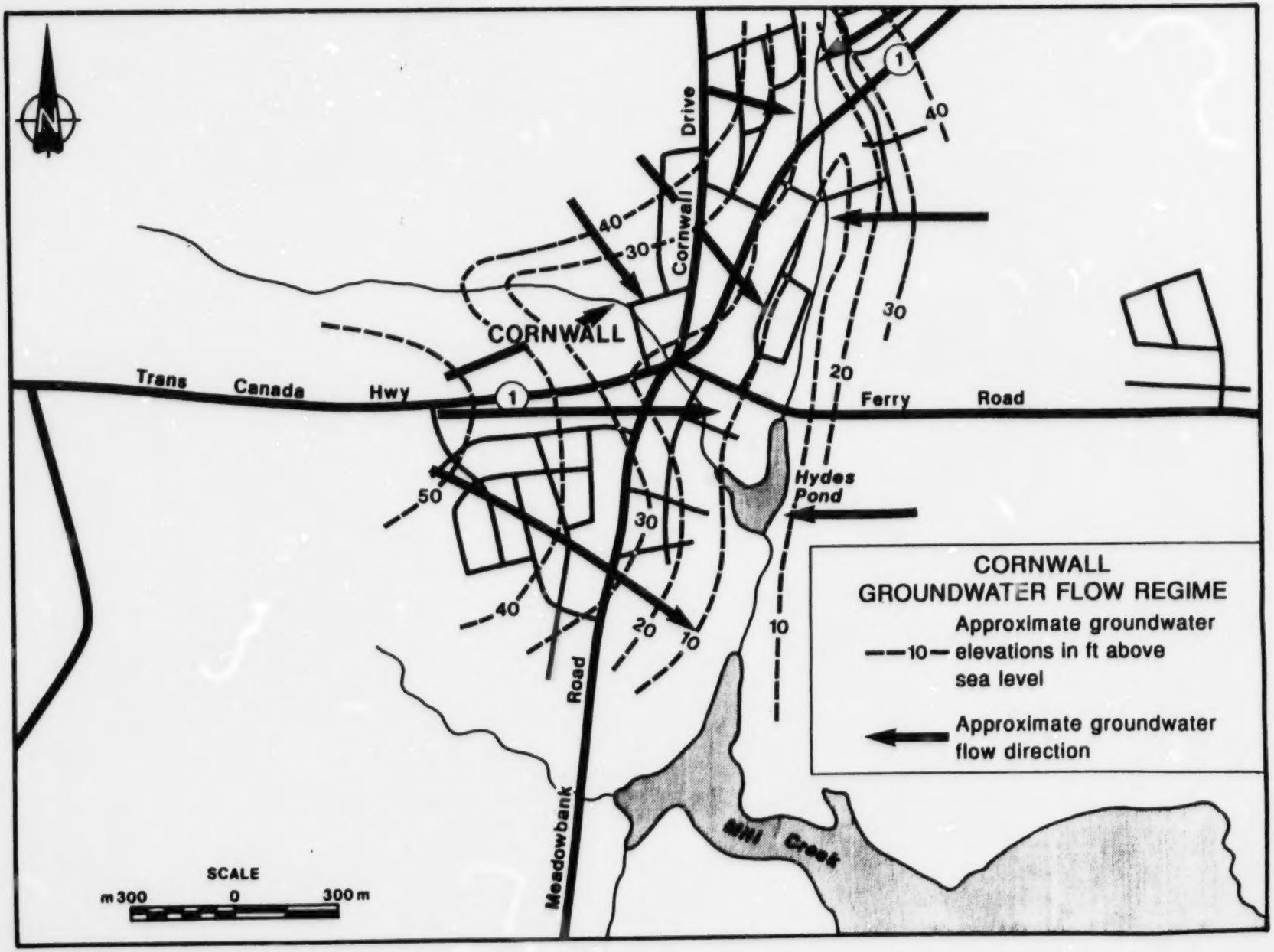

N
Cornwall Drive
CORNWALL
Trans Canada Hwy
1
Ferry Road
Hydes Pond
Meadowbank Road
Mill Creek
40
30
20
10
50
CORNWALL
GROUNDWATER FLOW REGIME
Approximate groundwater elevations in ft above sea level
10
Approximate groundwater flow direction
SCALE
m 300 0 300 m

Figure 6

potential contaminants traveling from more densely developed areas of the community.

Because most wells in the area are of approximately the same depth, it is difficult to approximate the vertical component of groundwater flow in the area. From available data, it appears that most of the region is an area of groundwater recharge, at least in the higher and more northerly parts of the community. Interestingly, the water levels at test well COR-2, site #1 did rise slightly as the well was drilled progressively deeper, suggesting a slight upwards hydraulic gradient in at least the higher portions of the hole (discharge conditions). At the same time a slight downward gradient was noted in the test hole drilled at site #2 in spite of its proximity to Hyde Creek and its position lower down in the basin. In general however, along the lower reaches of Hyde Creek, surface water levels and static water levels are more similar (considering the seasonal variations in static water level measurements) and it is likely that groundwater discharge occurs in these areas and is a major contributor to to the baseflow of the creek.

Further upstream on Hyde Creek and its tributaries, perennially wet areas (such as along the intermittent stream traversing the north western boundary of the community) where static water levels in wells are below apparent surface water levels, groundwater discharge may occur in localized, shallow flow systems while at greater depths the vertical gradient is downwards.

5.0 Groundwater Quality

5.1 Baseline Water Quality

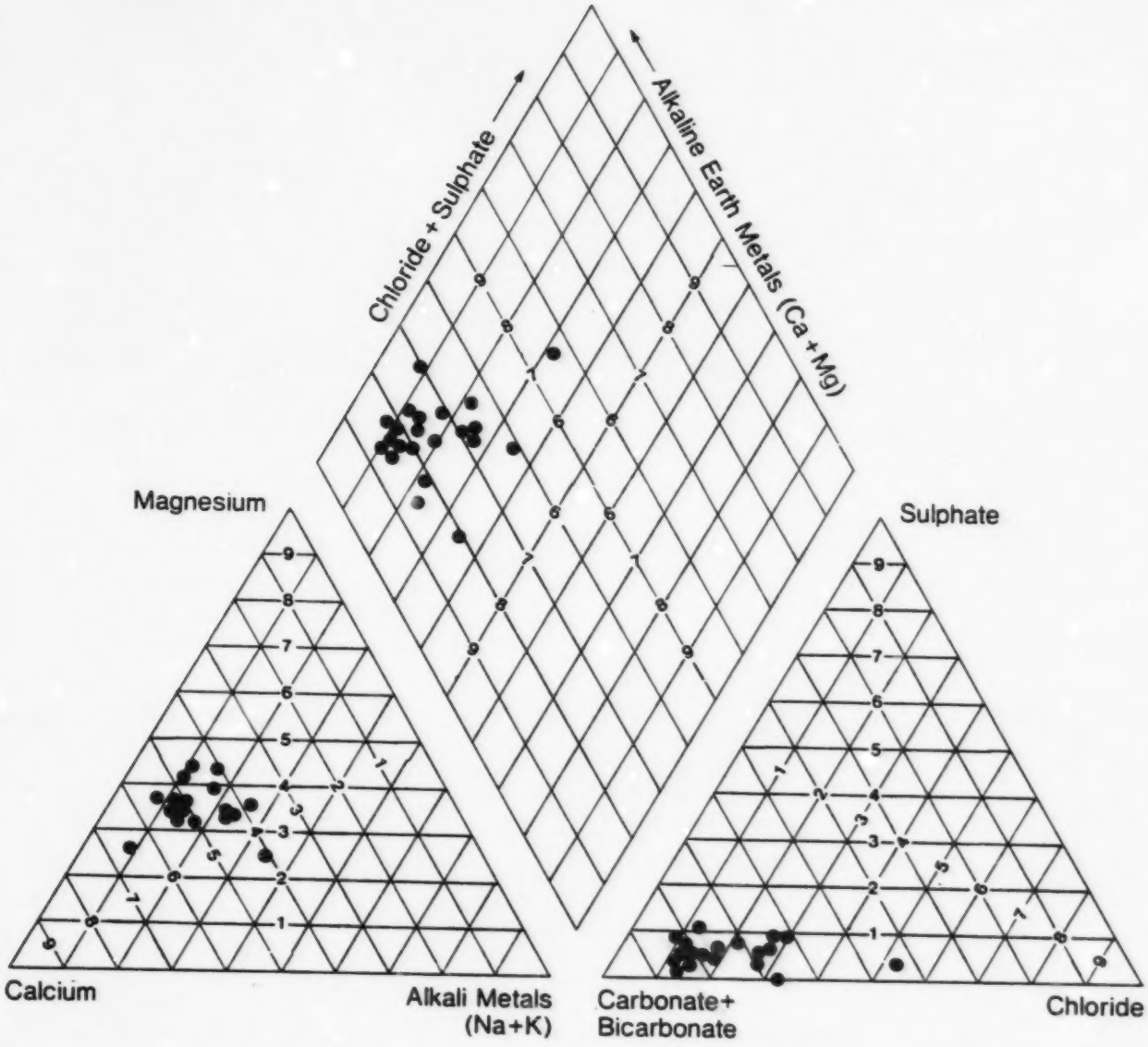
Water quality analyses indicate a moderately hard calcium bicarbonate groundwater. The most common water quality problems in the community are high bacteria counts. In addition there are a few random cases of high iron and manganese concentrations. In general though, water chemistry is well within the guidelines outlined by Health and Welfare Canada. The relative concentrations of the major ionic species form water samples collected in the community are depicted on the Piper diagram shown on Figure 7.

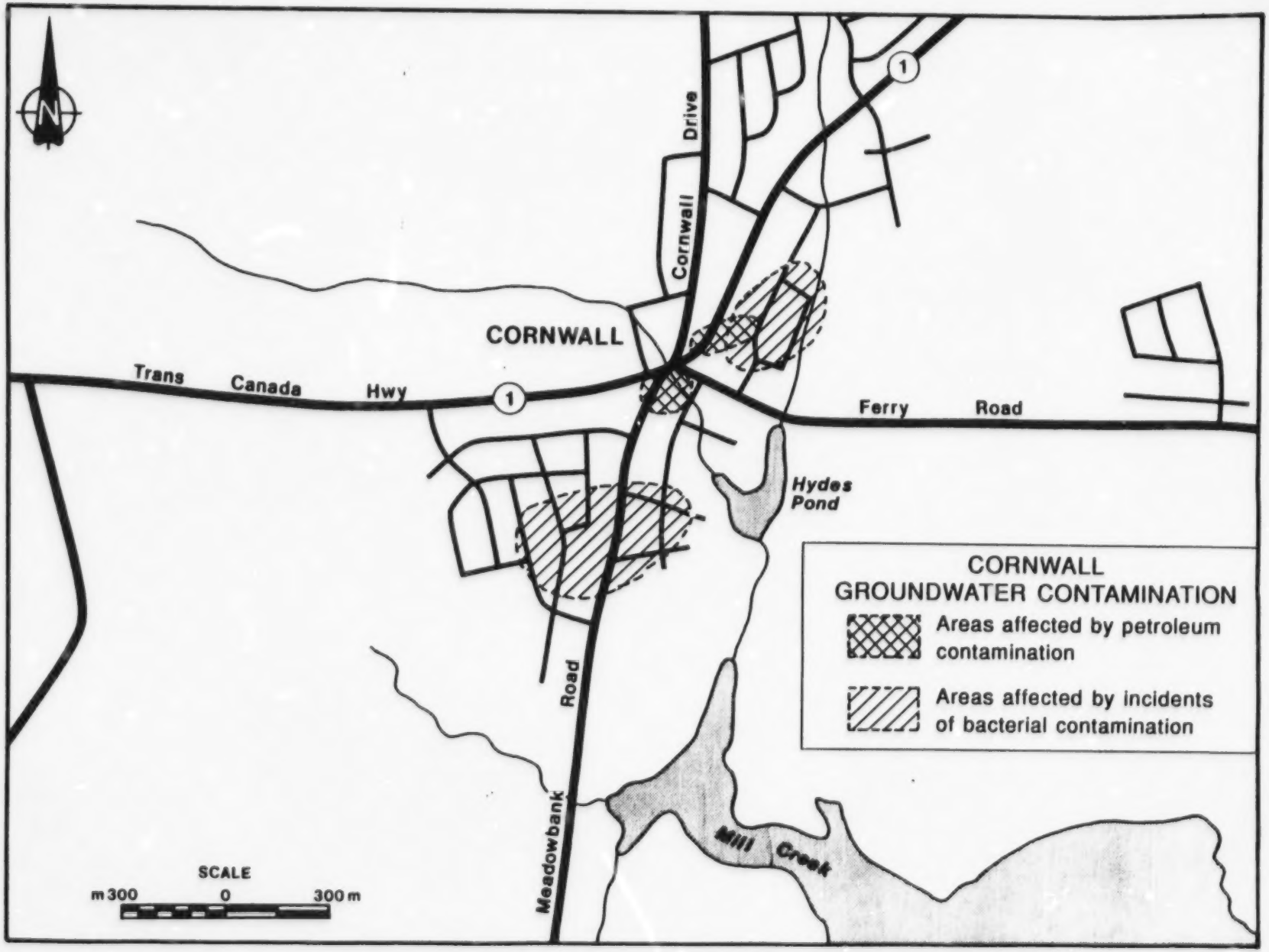
5.2 History of Water Quality Problems

There have been several gasoline spills in the community, one of which has affected at least 4 wells and another which has affected at least 1 well. The first occurred in the area of the Esso Service Station and the Cut Rite grocery store and has spread to the east. The exact source of this plume has not been determined. The second spill apparently occurred at the Shell service station with the contaminant plume spreading to the east towards Hyde Creek.

Periodic instances of high bacteria counts are wide spread over the community, and seem to be persistent over time. They appear to be naturally occurring bacteria as the community is serviced by sewer and assuming sewer integrity , the widespread nature of the contamination has been postulated to be due to shallow, permeable overburden.

Figure 7


Chloride + Sulphate
Alkaline Earth Metals (Ca + Mg)
Magnesium
Sulphate
Calcium
Alkali Metals
(Na+K)
Carbonate+
Bicarbonate
Chloride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Cornwall Drive
1
CORNWALL
Trans Canada Hwy
1
Ferry Road
Hydes Pond
Road
Meadowbank
Mill Creek
SCALE
m 300 0 300 m
CORNWALL
GROUNDWATER CONTAMINATION
Areas affected by petroleum contamination
Areas affected by incidents of bacterial contamination

Figure 8

Notwithstanding these apparently "natural" occurrences of bacteria in the groundwater, there have been incidents that suggest that leakage of the domestic sewage collection system has occurred, marked by the appearance of faecal coliform in water samples. It should be noted, that with the high density of wells in the area, the initial contamination of a single well by a leaking sewer lateral or main could easily lead to the contamination of a significant number of wells because of the multitude of potential pathways (ie. the uncased portion of this large number of wells) allowing migration of contaminants both laterally and deeper into the aquifer . It is concerns such as these which have led the community to embark on a program which will see the entire community serviced with a central water supply.

Similarly, even isolated spills of other potential contaminants could be expected to have a widespread effect in the area because of the density of individual wells. The combined influences of a relatively thin layer of overburden and dense residential development, depending on on - site water supplies, lead to a situation where the risk of groundwater contamination is relatively high. It is concerns of this nature which have led the community to embark on a program of central water servicing for the community.

The extent of areas which have been effected by petroleum contamination and frequent incidents of bacterial contamination are indicated on Figure 8.

Other potential sources of contamination in the community include the sewage lagoons which are located just south of Ferry Road, and underground storage tanks located service stations and several other locations. Particular attention should be given to the location and manner of construction of any wells drilled in these areas.

6. Planning Considerations

Currently the community is in the process of developing a central water system, which when completed will service the entire community. Until such time as all phases of the system are completed a significant number of residents will continue to rely on on-site water supplies (individual, privately owned wells). Given the density of development in the area, and the natural hydrogeological conditions, water quality issues are likely to continue to effect the community until all areas have central water servicing. For the same reasons that private well are vulnerable to contamination, it will be important to ensure that adequate consideration is given to the location and protection of the sources of supply for the central water system.

6.1 Availability of Water

Based on the current population of Cornwall and the expected growth trends for the community, the total water requirements can be estimated. In a study conducted by Delcom Consultants Inc. in 1984, it was estimated that the population of Cornwall would be expected to be 2860 by the year 2005 with an average daily water requirement of approximately 545 m^3/day

(6.3 L/sec.). Peak flow requirements are usually considered to be two to three times daily average flow rates (approximately 19 L/sec), with provision for pumping when the main pump is out of service.

Based on these considerations it is suggested that a groundwater resource with a capacity of approximately 19 L/sec. should be developed, which should be adequate to handle normal water requirements. Additionally it would be advisable to at least identify an additional capacity of 10 - 15 L/sec., and to adopt measures which will ensure the protection of this additional resource, to provide for backup capability for the system in the event of mechanical failure or accidental contamination of some portion of the water supply.

Pump testing under in connection with this study indicates that only limited quantities of water could be withdrawn from the two test wells constructed at site #1, with a probable combined yield of 6 L/sec. or 522 m^3/day at the very most. More rigorous testing of these wells would be required to confirm this value.

The results of pump testing of test hole COR-3 at site 2 suggest that at least 19 L/sec. or 1636 m^3/day could be with drawn from this well.

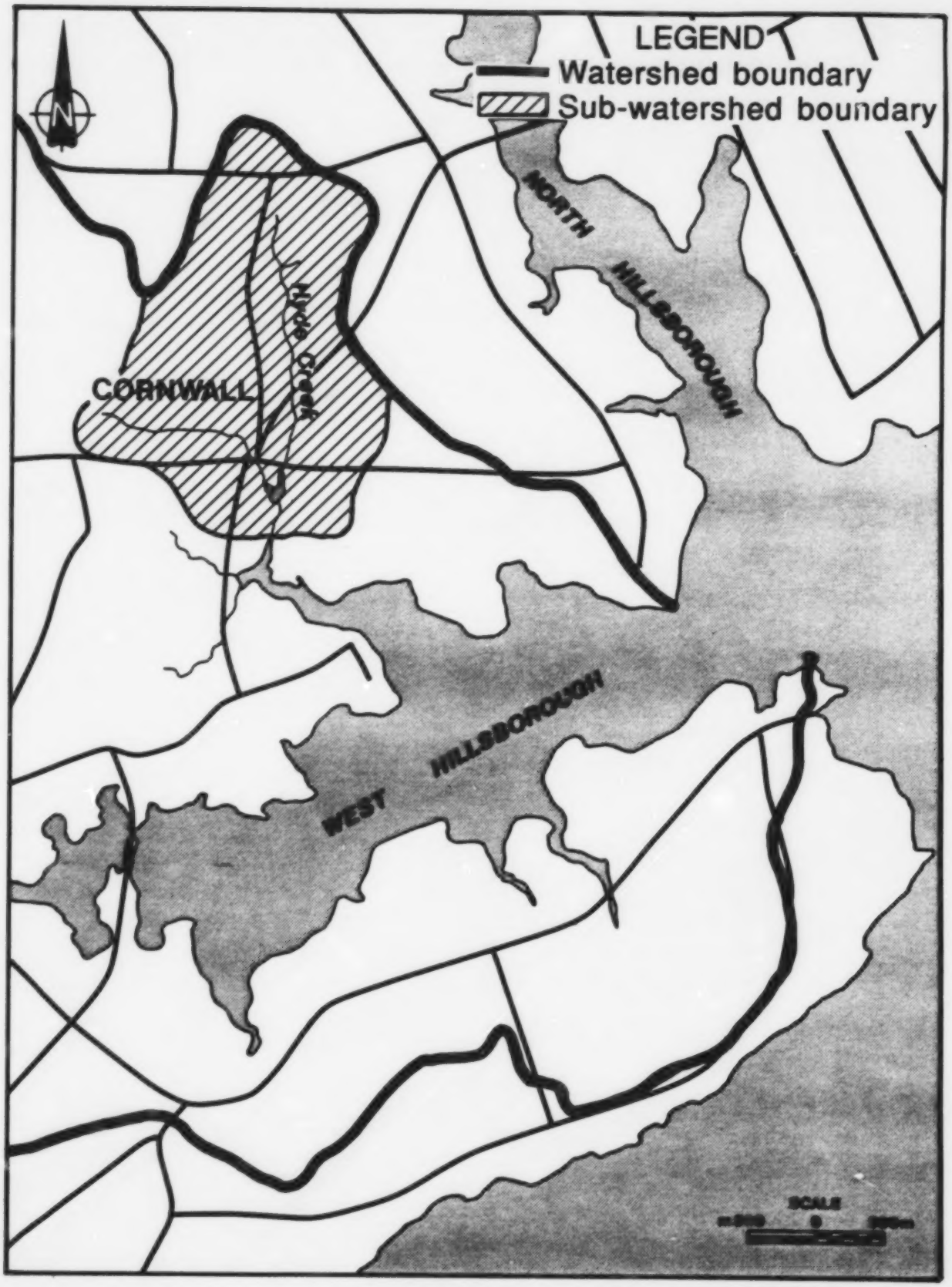
In addition the well servicing the Elwin Jay subdivision in the north eastern part of the community appears to be capable of supplying approximately 5.3 L/sec., thus these four wells would be capable of supplying a total of 30 L/sec. (2618 m^3/day) sufficient to meet the community's needs for the foreseeable future.

When considering any area for the development of a water supply which will involve substantial groundwater withdrawals, it is important to ensure that the area under consideration can support the required level of pumping without creating adverse effects for other water users. This includes not only the consideration of possible effects on other wells in the vicinity, but involves as well any impact on the contribution of groundwater to surface water flows (ie. any reduction of baseflow to streams in the watershed).

On Prince Edward Island, surface water divides and groundwater divides are generally thought to coincide (Francis, 1989), allowing the delineation of hydrogeological regimes into systems based on surface watershed extent. The level of groundwater withdrawals possible without adverse impacts on other water users is a function of the areal extent of the portion of the watershed contributing water to the well field or fields, and can be based on the amount of available recharge. In the case of this study, all areas of interest lie within the Hyde Creek sub-watershed. The area potentially contributing groundwater to potential well fields which might supply the community covers approximately 7.73 km^2 (shown as the shaded area on Figure 9.)

For the purposes of this report it can be assumed that up to 50% of the available recharge may be safely withdrawn without adversely effecting stream flows in the area. Typical recharge

Figure 9


LEGEND
Watershed boundary
Sub-watershed boundary
N
CORNWALL
NORTH
HILLSBOROUGH
WEST
HILLSBOROUGH
SCALE

rates on the Island are in the range of 35% of annual precipitation which averages 1100 mm. Using these assumptions it can be concluded that the area under consideration could support groundwater withdrawals in the neighborhood of 47 L/sec. or 4045 m^3/ day, more than twice the expected needs of the community in the foreseeable future.

An assessment of the availability of water should also include consideration of the vulnerability of the water supply. Two factors need to be considered here; the vulnerability with respect to volume requirements, and the vulnerability of the water supply to contamination.

Vulnerability of supply

Of the potential 2618 m^3/day water supply identified above, nearly two thirds is identified with a single well (Test hole COR-3 at test site #2). Any disruption in pumping from this supply could cause severe strain on a water system, if it were relied on to meet the bulk of the communities needs. It therefore would be prudent to develop sufficient capacity from a number of wells to reduce dependency on any single source of supply.

As a more immediate consideration, the well currently supplying water to the Elwin Jay subdivision has more than adequate capacity to meet current needs, but no back up supply is available should pumping from this well be disrupted.

Vulnerability to contamination

The test wells at site #1 are a considerable distance from most obvious sources of contamination, with the possible exception of the application of agriculture chemicals on the adjacent agricultural lands or the possibility of a spill of some hazardous materials on the Trans Canada Highway, which although fairly distant from the site, is up grade from the wells. While as has already been indicated , only a small portion of the community' water supply could be met by these wells, protection of groundwater resources in this area should be a fairly straight forward matter.

The test well COR-3 drilled at site #2, on McArthur Drive is situated in a densely developed area, relatively vulnerable to contamination, with both surface water and groundwater flow from the central portion of the community being towards the well.

Results from pump testing suggest that bedrock in the area has a relatively high transmissibility (ie. water is transmitted through the aquifer with relative ease). All other factors being equal, this would suggest that the cone of depression (the portion of the aquifer for which water levels or hydraulic head are effected by pumping) created by pumping this well would be shallow, but of large areal extent.

This raises the possibility that potentially contaminated groundwater which does not currently flow towards the well under the natural hydraulic gradient could be induced to flow towards the well during heavy pumping. As has been noted in the discussion on water quality, several petroleum spills have been documented in this area of the community, including one small spill which is almost directly up gradient of the well even under the influence of the natural groundwater flow regime alone.

The well currently servicing portions of the Elwin Jay subdivision in the north eastern part of Cornwall is situated in a more favorable location than test hole COR-3 with regard to the potential for contamination. Nonetheless, there is only a limited amount of land surrounding the well for which effective well head protective measures could be adopted, and the potential for contamination through incidents such as a sewer line break, application of road salt etc., is still present. If such an event were to occur, no alternate source of supply is presently available for this area.

In summary then, while sufficient groundwater resources to meet the expected requirements of the community have been identified, caution should be exercised in selecting the location of production wells as this supply could be relatively vulnerable to contamination. In particular while test well COR-3 may be a tempting source of supply due to its high yield, it is in a poor location with regards to potential groundwater quality problems.

Further test drilling immediately across Hyde Creek from test well COR-3 should identify additional groundwater resources in an area less prone to contamination, and where substantial well yields could be anticipated. It is likely that the converging groundwater flow pattern (see Figure 6) which roughly parallels the course of Hyde Creek would act as an effective hydrogeological barrier to the migration of potential contaminants from the central area of the community towards this site, at least at depths to which potential water supply wells are likely to be constructed. Additional supplies developed in this area could reduce dependence on supplies in areas more vulnerable to contamination.

6.2 Groundwater protection strategies.

The importance of groundwater resources to the health and welfare of Island communities is well recognized. To a lesser extent, the importance of implementing sound, far sighted strategies aimed at protecting this valuable resource is also appreciated. The following discussion attempts to provide some focus to the issue, by presenting some possible approaches to the development of a comprehensive groundwater protection strategy.

The issue of groundwater protection can be separated into two components: specific requirements for the protection of central water supply wells or well fields; and general considerations pertaining to the protection and preservation of ground water resources in general.

It is worth commenting at this point that even if a community is not actively developing a central water supply (or additional supply), it is in the community's interest to be aware of their existing resources, and to know what requirements and constraints would be involved in the management and development of its groundwater resources. Ideally this exercise would involve the identification of suitable locations for the future development of groundwater supplies and the development of appropriate strategies to protect this resource.

Well Field Protection

Unlike the processes that lead to the contamination of surface water bodies, the degradation of groundwater resources is not subject to direct observation, and consequently more difficult to predict and correct. Once contaminants have been introduced into a groundwater system, their migration and fate is governed by a complex series of reactions and processes which depend on a number of parameters which may be only poorly documented . Consequently the prediction of the consequences of the introduction of contaminants into a groundwater reservoir in the vicinity of wells supplying a water supply system requires a number of approximations and assumption of varying validity.

A number of approaches have been developed to provide varying degrees of protection to wells supplying central water systems. In general , the object of these strategies is to designate an area around the well or well field, for which activities which have the potential to have an adverse effect on the water supply are restricted or prohibited. Frequently, a number of concentric zones around a well or well field are defined, with progressively lighter land use restrictions for each zone with increasing distance from the well or well field.

"The major parameters in developing groundwater protection strategies for municipal water wells are legal, socio-economic, and hydrogeological" (Alan Gregory, 1988). In this report suggested protective strategies are based primarily on hydrogeological parameters. It is recognized that the modification of these strategies in the light of socio - economic factors may be necessary, however the principles behind them do provide a defensible, technical basis for decision making regarding the protection of groundwater resources.

There are a wide variety of techniques which have been employed groundwater protection zones. The three types of zones considered in this study are defined below:

1) **Radius of Influence** - The areal extent of the cone shaped depression in the water table or in the pieziometric surface resulting from the pumping of water from a well or well field. Within this area it is recommended that no residential, commercial or industrial development take place, and that restrictions be placed on agricultural activities. The area would however be suitable for the development for some types of recreational activities.

2) **60 Day Delay Time Zone** - An area enclosed by a line representing the distance from which potential contaminants are expected to migrate towards a well or well field in a given period of time under pumping conditions. Within this area, it is recommended that on site sewage disposal be prohibited (ie. no septic systems) and the storage, or handling of hazardous materials including petroleum products be prohibited. In addition, any other development proposals or activities should be subjected to an environmental impact assessment.

3) **Recharge Area** - A zone outlining the area in which groundwater is expected to flow to the well both under pumping conditions and the existing natural hydrogeological flow regime. Within these areas, major development proposals or proposed land use changes which have the potential to effect the environment should be first subjected to an environmental impact assessment.

These methods have the appeal that they can be based on the actual characteristics of the aquifer, and thus can be justified to some extent on the basis of their scientific foundations. It should be noted at the outset however, that rarely are aquifer characteristics sufficiently well known that the suggested protection zones provide an absolute guarantee of protection. Nonetheless, these approaches can help in developing rational water management policies, which can be refined and improved as additional information or insight into actual field conditions is accumulated.

Each of these approaches has strengths and weaknesses, and it is perhaps advisable to develop well field protection strategies, which incorporate the most appropriate aspects of each approach. The following considerations may form the basis for such a strategy. The hydraulic characteristics of the areas surrounding the three test holes constructed as part of this program, and the well servicing the Elwin Jay Subdivision are used here as examples of how these zones might be defined in practice. The results of this exercise are shown on Figure 10.

Radius of Influence:

When water is being pumped from a well, the water table (or hydraulic head in the surrounding area is depressed, creating a change (increase)in the natural hydraulic gradient towards the well. The extent of this " cone of depression" represents the radius of influence of the well or well field.

Various techniques can be employed to estimate the extent of the radius of influence, which will depend on the duration and rate of pumping, aquifer characteristics, and other

hydrogeological parameters. Some parameters exhibit temporal variability (eg. recharge to the aquifer) while other factors may exhibit spatial variability, thus certain simplifying assumptions usually must be made in order to determine the extent of the zone.

It is assumed here for instance, that all pumping is at a constant rate for a duration of 180 days without any recharge to the aquifer. Furthermore, aquifer parameters, such as hydraulic conductivity and storativity are assumed to be uniform over the entire areal extent of the area under consideration, and are reasonably represented by values obtained from the available pump test data.

Because from a theoretical stand point, the areal extent of the cone of depression may be infinite, some practical boundary must be assumed. For the purposes of this study, this boundary is drawn at the point where the gradient induced by pumping is equal to or less than the natural hydraulic gradient (ie. at a distance where it is difficult to distinguish the effects of pumping on the natural hydraulic gradient).

Typically, in fractured sandstone aquifers on P.E.I., the upper portions of the aquifer have significantly higher permeabilities then at greater depths (due primarily to increased fracture frequency (Francis, 1989) thus in deriving hydraulic conductivity values from pump test data, it is assumed that the total contribution of water from the well is from the top 30 m of open hole, regardless of the actual well depth.

Based on these assumptions, the radii of influence for test holes COR-1, 2 and 3 and the well servicing the Elwin Jay Subdivision have been estimated.

For the well servicing the Elwin Jay subdivision, pumping at a constant rate of 4.5 L/sec., the radius of influence is an elliptical shaped zone extending up gradient from the well approximately 120 m and with a downslope extent of approximately 75 m as depicted in Figure 10.

The predicted radius of influence for test hole COR-3 on McArthur Drive, is approximately 75 m in an up slope direction and 30 m in the down slope direction although Hyde Creek is likely to form an effective recharge boundary at this point in any event.

Because of the lack of reliable aquifer data for test wells COR-1 & 2 in the north west part of the community, it is not possible to determine the radius of influence for these wells with any great degree of certainty and the radii of influence for these wells is not shown.

Delay Time Zone

The rate at which a potential contaminant can travel towards a well is a function of a number of factors including the nature of the aquifer materials, the natural hydraulic gradient , and the hydraulic gradient induced by pumping the well or wells.

As might be expected, the higher the pumping rate, the more rapidly a contaminant will travel towards the well, and the larger the radius of the delay time zone around the well or well field will be.

A convenient starting point would be to identify a 60 day delay time zone. A zone of this size should provide protection against most pathogenic organisms (60 days is the maximum time most pathogenic organisms area believed to survive in groundwater), and could also provide a sufficient buffer zone that an alternate well location could be adopted if a particularly serious incidence of contamination threatened the water supply.

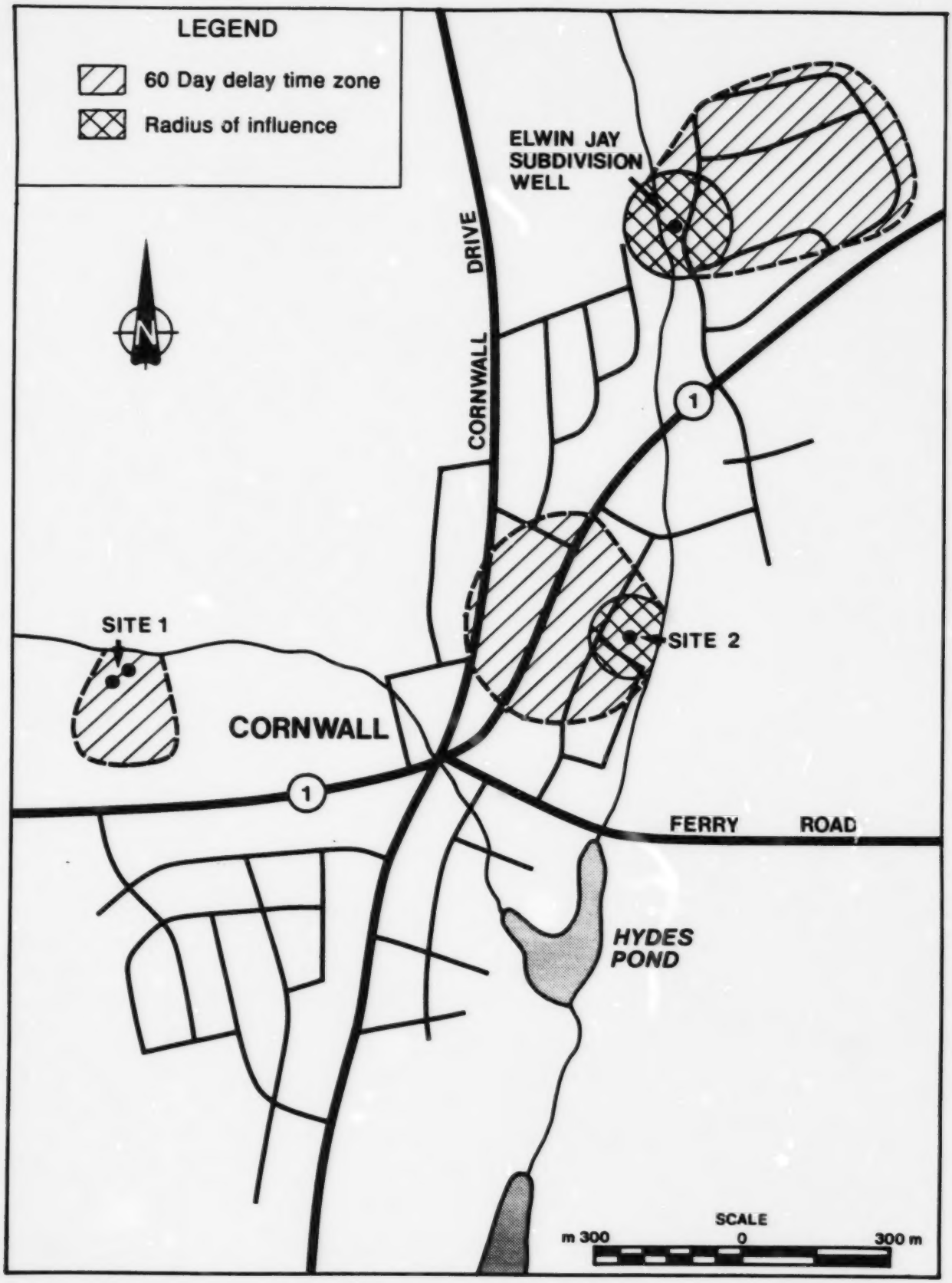
Thus if for instance a spill of hazardous material occurred at the edge of this zone, the community would have approximately 60 days in which to take what ever remedial measures were possible before the contaminant would be expected to reach the well. It should be noted that this would apply to contaminants which could travel as rapidly as the groundwater, such as readily soluble species. Many other materials would travel considerably more slowly, because of different viscosities, densities or because of adsorbtion by or reaction with the aquifer materials.

Shown also on Figure 10 is the approximate outline of the 60 day delay time zones around the wells at site #1 & 2 as well as the well servicing the Elwin Jay Subdivision. It should be noted of course that these areas have been calculated on the basis of existing pump test data and certain simplifying assumptions regarding the geological characteristics of each site and the size of the zones could be refined as further information on the areas accumulates.

In each case it will be noted that the 60 day delay time zone extends a great deal further in the upslope direction than in the down slope direction, and in each case in fact extends the entire up slope distance to the nearest topographic divide. This is perhaps less surprising when one considers the fact that groundwater would be expected to travel a considerable distance downslope in the same time period towards the well under the natural hydraulic gradient alone, with out any pumping, particularly where the hydraulic conductivity of the aquifer is high, as in the case at test hole COR-3 and the well in the Elwin Jay subdivision. For this reason the 60 day delay time zone in effect encloses the entire recharge area for each of these wells, and no separate recharge area need be defined for protection.

It should be noted in calculating the size and shape of these zones, that the transmissibility values determined from pump test data was derived from pumping well data, and as such does not give any indication of possible anisotropy of the aquifer. In fact the large differences noted

Figure 10


LEGEND
60 Day delay time zone
Radius of influence
ELWIN JAY SUBDIVISION WELL
CORNWALL DRIVE
N
1
SITE 1
SITE 2
CORNWALL
1
FERRY ROAD
HYDES POND
SCALE
m 300
0
300 m

for transmissibility between site #1 & #2 while accounted for in the calculation of individual zones, do illustrate the lack of uniformity in aquifer properties in this area. Consequently the catchment areas and delay time zones defined here are determined on the assumption of a homogenous, isotropic aquifer, even though it is possible that the aquifer is extremely anisotropic with respect to transmissibility, and the actual extent and shape of these zones may be quite different. Only through the accumulation of more data on aquifer properties however, can these concerns be resolved.

General Groundwater Protection Measures

It is more difficult to describe, in any comprehensive manner the types of measures which will help to protect the overall groundwater resources of areas outside the specific recommendations outlined for the protection of central production wells or well fields. In general the most important element is probably a heightened awareness of the importance of groundwater resources to the community, and keener appreciation of the nature of this resource and the interaction between man's activities and the natural environment.

There are a multitude of ways in which this awareness can be applied to maintain or enhance the quality of our environment without having to become an expert in the field of hydrogeology, but the most important aspect is to adopt a pro-active approach to planning, and to consider the potential impact of activities or developments which may have an effect on groundwater quality prior to proceeding with them.

In the preceding sections relating to the protection of production wells or well fields, it was recommended that a proper environmental impact assessment be conducted for any developments which potentially could have an impact on groundwater quality. Adherence to the same approach to development regardless of its proximity to a central water supply area can't help but provide greater protection to groundwater resources, including resources which may have to be called upon at some unforeseen time in the future.

Regrettably, there will always be situations where problems will occur resulting at least in part from activates carried out before the integrity of groundwater resources was a high priority, or where a potential threat to groundwater quality was unknown or unavoidable. Still measures can be taken to minimize the adverse impact of such events.

In areas where it is known that soil conditions render on-site water supplies more vulnerable to contamination, and yet alternative means of water supply are not available or practical, the adoption of more stringent well construction standards would reduce both the incidence and extent of contamination.

Similarly, in areas relying on on-site water supplies, and where contamination of wells has occurred due to improper or careless handling, storage or use of materials such as road salt,

petroleum products or agricultural chemicals, steps can be taken to minimize the risk of future contamination through modification of the manner of handling these materials, and more stringent well construction standards.

As an example, the use of road salt could be minimized in areas which have been shown to be particularly susceptible to contamination by salt, while at the same time new wells constructed in the area could be required to have additional lengths of casing, properly grouted to also reduce the likelihood of contamination.

7. Conclusions and Recommendations

The results of this investigation indicate that there is an abundant quantity of groundwater in the Community of Cornwall, but this resource is relatively vulnerable to contamination under existing conditions (natural hydrogeological conditions, dense development and dependence primarily on on-site water supplies)

As the Community of Cornwall continues to develop, it is likely that incidences of groundwater contamination will increase. The provision of a central water supply service to part or all of the community is likely to greatly improve this situation.

Test drilling and pump testing activities conducted as part of this investigation as well as data collected previously, identify an adequate groundwater resource to meet the requirements of a central water supply system. At the same time it is apparent that a considerable portion of the resource identified here is at some risk to contamination primarily due to its proximity to heavily developed parts of the community, and it's position in the groundwater flow regime.

It is recommended therefore, that further exploratory work be conducted to confirm the presence of sufficient quantities of potable groundwater, in areas less susceptible to contamination. In particular it is recommended that additional test drilling be conducted across Hyde Creek from test site #2 of this program. It is anticipated that the aquifer characteristics of this area will be similar to those found at site #2 and that substantial quantities of water could be withdrawn from this area without the same risk of contamination of the water supply.

It is also recommended that an additional well be constructed as a backup supply in the Elwin Jay subdivision. Again it is anticipated that a substantial supply of water could be developed in this area, which would add greater security to the existing supply in this area as well as perhaps augmenting supply to other parts of the community, providing of course that central water is to be supplied to a greater portion of the Community of Cornwall.

While the quantity of extractable groundwater identified at test site #1 was disappointing, the site is situated in a location where groundwater protection measures would probably be rela-

tively easy to implement. Further testing of these two wells would provide more data on the aquifer parameters in this area of the community at minimal cost, and would allow a more rigorous assessment of the potential of this site as a source of groundwater supply.

The adoption of well field protective measures as outlined in section 6.2 of this report, would of course be advisable both for the well field supplying the existing portions of the central water system and for sources of supply which might be developed in the future. Even if these areas are not developed as production sites in the near future, it is recommended that protective measures be adopted, so that the resource is protected for future use, if it is required. Ideally, the same measures suggested for actively used wells or well fields should be adopted , especially those outlined for the delay time zone and the recharge areas.

On a more general front, an increased awareness of the nature of the community's groundwater resources, and the impact of our day to day activities on groundwater quality will aid in the wise management of this resource. It is hoped that this report will provide at some guidance in this regard.

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APPENDIX I

WATER WELL DATA

CORNWALL

WATER WELL DATA

Name	Date	East. (m)	North. (m)	Depth (ft)	G.S. Elev. (ft)	S.W.L. - (ft)	Casing Length (ft)	Yield (lgpm)	Time (min)	Geology	Aquifers (Water Occurrences)
Claude MacPhee	790622	481100	5119200	90	80	40	42	8	10	0–20 Till, clay and boulders 20–90 Sandstone, some claystone	82 84 86 90
H. Herlihy	720610	481800	5119200	90	97	84	38	8	15	0–25 Fractured sandstone 25–90 Sandstone	40 84
Glen Wigginton	840617	481800	5119000	120	125	80	40	8	10	0–11 Sand till 11–120 Sandstone and claystone	75 85 105 115
Reginald MacKinnon	880602	481800	5119000	84	100	45	43	8	7	0–8 Till 8–84 Sandstone, some claystone	79 79
Lewis MacDonald	721030	482000	5119000	105	125	67	32	15	10	0–29 Clay till 29–105 Claystone and sandstone	86 86
Bonnie MacLean	821112	482000	5119000	110	90	70	42	8	7	0–8 Till 8–70 Layered sandstone and claystone	82 85 105 108
Pollard and MacPhee	780918	482100	5119104	142	120	60	42	8	8	0–14 Clay till 14–142 Sandstone, some claystone	80 83 110 113 130 138
Gary Paynter	880823	482100	5119200	100	120	45	40	8	15	0–15 Clay 15–100 Sandstone, some claystone	85 88
Michael LaFontaine	860625	482100	5119200	100	125	30	60	8	10	0–15 Clay 15–100 Sandstone, some claystone	
B. MacPhail	720731	482100	5119304	98	100	35	32	15	10	0–20 Clay 20–98 Sandstone and claystone	84 84
Scott Brothers	770630	482200	5119300	100	110	40	41	8	10	0–7 Sand till 7–100 Sandstone, some claystone	85 90 80 100
Harvey Butler	860730	482200	5119300	125	100	42	42	8	10	0–15 Clay 15–125 Sandstone, some claystone	85 88
Wayne MacPherson	781027	482300	5119500	103	75	40	40	8	20	0–6 Soft sandstone 6–103 Sandstone	85 88 95 105
Wayne MacPherson	781024	482300	5119500	105	75	40	40	8	20	0–6 Soft sandstone 6–105 Sandstone	85 88 95 105
Dave Roberts	781010	482200	5119000	130	110	88	38	15	10	0–15 Till 15–130 Claystone, some sandstone	120 123
Wendell MacDonald	770821	482300	5119400	109	100	30	40	10	8	0–38 Clay till 38–109 Claystone and sandstone	44 47 66 71
Wendell MacDonald	780722	482301	5119503	144	125	45	45	10	10	0–11 Clay till	80 83 105 108 130 133

Name	Date	East. (m)	North. (m)	Depth (ft)	G.S. Elev. (ft)	S.W.L. (ft)	Casing Length (ft)	Yield (igpm)	Time (min)	Geology	Aquifers (Water Occurrences)
										11–144 Sandstone, some claystone	
C. C. School		482331	5118814	150	102		56	10		0–9 Clay till	75 85 140 145
										9–150 Sandstone, some claystone	
W. MacRae	760610	482399	5119193	98	100	44	35	10	6	0–34 Clay till	62 65 79 82
										34–98 Sandstone and claystone	
Delmar Fritzsell	861029	482400	5119050	100	100	61	42	8	10	0–15 Till, shale, claystone	66 70 86 87 90 91
										15–100 Sandstone, some claystone	
Neil MacFadyen	730427	482400	5118994	96	100	42	27	8	15	0–6 Clay till	84 91
										6–96 Sandstone, some claystone	
Jay Arley	790720	482400	5119650	110	100	50	54	8	7	0–3 Till	85 88 103 106
										3–110 Sandstone, some claystone	
Pollard and MacPhee	750501	482401	5118294	147	95	40	42	8	15	0–12 Clay till	86 90 120 126
										12–147 Sandstone	
Scott Brothers	750824	482401	5118494	138	75	32	44	8	15	0–6 Clay till	80 86 125 130
										6–138 Sandstone, some claystone	
Mervin MacDonald	740903	482402	5118794	147	100	56	44	8	10	0–15 Clay till	80 83 108 108 140 146
										15–147 Sandstone, some claystone	
Terry MacDonald	860620	482450	5118800	120	100	66	52	8	7	0–19 Till, claystone, silt	70 73 110 113
										19–120 Sandstone, some claystone	
Scott Brothers	740903	482499	5118794	146	110	52	43	8	10	0–24 Clay till	80 83 95 98 126 143
										24–146 Sandstone, some claystone	
Armand Taylor	790200	482500	5118300	108	80	27	41	20	10	0–41 Clay till	43 46 89 92 90 98
										41–108 Sandstone, some claystone	
Mervin MacDonald	751022	482500	5118500	118	85	36	33	8	15	0–19 Clay till	79 75 105 110 87 89
										19–118 Sandstone, some claystone	
Lloyd Scott	750721	482503	5118494	115	75	26	36	8	15	0–14 Clay till	80 85 106 110
										14–115 Sandstone, some claystone	
Willard MacLeod	760517	482600	5118400	124	80	46	34	10	6	0–33 Clay till	67 70 107 110
										33–124 Sandstone, some claystone	
Willard MacLeod	760514	482600	5118600	122	80	45	33	10	6	0–28 Clay till	68 69 104 107
										28–122 Sandstone, some claystone	
Armand Taylor	790601	482600	5118700	130	125	56	43	10	8	0–40 Clay till	118 119
										40–130 Sandstone and claystone	
Ron MacDougall	870709	482600	5118700	121	100	57	43	8	10	0–20 Till, claystone	57 61 88 93 115 121

Name	Date	East. (m)	North. (m)	Depth (ft)	G.S. Elev. (ft)	S.W.L. (ft)	Casing Length (ft)	Yield (igpm)	Time (min)	Geology	Aquifers (Water Occurrences)					
										20–121 Sandstone, some claystone						
Willard MacLeod	780505	482800	5118793	136	100	37	83	10	10	0–20 Till	82	130				
										20–136 Sandstone, some claystone						
Fred Sobey	780514	482800	5119000	90	125	35	45	8	7	0–2 Till	81	84				
										2–90 Sandstone, some claystone						
V. David MacPhail	780106	482801	5118883	100	100	28	34	15	10	0–30 Till	90	95				
										30–100 Sandstone and claystone						
David MacPhail	740809	482801	5118992	133	75	48	22	15	10	0–28 Clay till	130	123				
										28–133 Sandstone and claystone						
G. Lowther	720329	482882	5118793	115	75	30	48	15	10	0–25 Clay till	85	88				
										25–115 Sandstone, some claystone						
Everett Boyle	780618	482700	5117900	130	70	40	130	10	5	0–28 Till	90	93	122	125		
										28–130 Sandstone and claystone						
Willard MacLeod	780716	482700	5118000	103	75	30	30	10	5	0–22 Clay till	85	88				
										22–103 Sandstone						
David MacPhail	720622	482700	5118000	120	110	35	35	15	10	0–35 Clay	120	125				
										35–120 Sandstone and claystone						
Clifford MacQuaid	870606	482700	5119000	117	125	45	41	8	10	0–25 Till, claystone	43	46	70	73	110	117
										25–117 Sandstone, some claystone						
Mack MacLean	781117	482700	5119000	153	100	72	39	8	10	0–14 Clay	90	93	140	143		
										14–153 Sandstone and claystone						
David MacPhail	740825	482702	5118883	179	100	75	28	15	10	0–32 Clay till	170	173				
										32–179 Sandstone and claystone						
K. Scott	721018	482703	5118484	77	85	30	30	8	5	0–27 Clay and sandstone	65	75				
										27–77 Sandstone						
Gary Paynter	860520	482900	5118800	106	100	30	41	8	10	0–10 Clay	85	88				
										10–106 Sandstone, some claystone						
Ross Burgoyne	850320	482850	5118850	105	80	25	47	8	8	0–3 Till	80	83	95	98		
										3–105 Sandstone, some claystone						
William Scott	870614	482900	5118400	100	75	45	44	8	10	0–25 Till, claystone	48	50	85	90		
										25–100 Sandstone, some claystone						
Gary Paynter	850702	482900	5118800	100	100	30	40	8	10	0–10 Clay	80	83				
										10–100 Sandstone and claystone						
Stephen MacEachern	860204	482900	5119000	83	100	30	43	10	10	0–23 Sandy till, clay and sandstone	80	85	70	80		

Name	Date	East. (m)	North. (m)	Depth (ft)	G.S. Elev. (ft)	S.W.L. (ft)	Casing Length (ft)	Yield (igpm)	Time (min)	Geology	Aquifers (Water Occurrences)					
										23–83 Sandstone, some claystone						
David Johnstone	730726	483000	5118994	87	75	25	30	15	10	0–27 Clay till	75	79				
										27–87 Sandstone, some claystone						
Kevin MacDonald	761116	483000	5119000	81	75	30	32	8	5	0–12 Till	37	40	69	71		
										12–81 Sandstone and claystone						
Hector Scott	760815	483000	5119700	87	75	37	35	8	5	0–25 Clay till	54	57	72	76		
										25–87 Sandstone and claystone						
Leo MacDonald	730813	483049	5118383	70	75	23	42	15	10	0–40 Till						
										40–70 Sandstone, some claystone						
Leyton Burgoyne	850812	483080	5116800	100	75	46	43	15	5	0–3 Till	46	49	88	91		
										3–100 Sandstone, some claystone						
Keith Carmichael	781116	483080	5118800	116	80	26	90	8	10	0–9 Sandstone	99	83	106	108		
										9–116 Sandstone, some claystone						
Rooney Walsh	700708	483080	5118900	77	80	27	23	8	15	0–17 Fractured sandstone	36	39	72	75		
										17–77 Sandstone and claystone						
Moffett's Shell	770530	483080	5119050	150	75	30	119	8	10	0–2 Till	148	151				
										2–150 Sandstone, some claystone						
Cornwall Post Office	821020	483080	5119200	100	25	22	84	20	5	0–10 Till	85	88	92	95	94	97
										10–100 Sandstone, some claystone						
Glen Scott	791105	483080	5119600	95	80	30	44	8	7	0–3 Till	86	89	88	91		
										3–95 Sandstone, some claystone						
Murphy	720516	483090	5119190	105	100	15	34	10	15	0–10 Clay						
										10–105 Sandstone, some claystone						
Wendell MacDonald	771103	483100	5120300	91	75	31	36	10	9	0–34 Clay till	40	43	66	71		
										34–91 Sandstone and claystone						
Wendell MacDonald	771108	483100	5120400	87	75	25	18	10	9	0–17 Clay till	29	32	42	45	66	71
										17–87 Sandstone, some claystone						
Wendell Macdonald	741105	483102	5118892	92	40	20	31	8	15	0–16 Clay till	35	40	80	86		
										16–92 Sandstone						
Jimmy Beers	760102	483102	5118892	76	80	18	28	15	10	0–25 Till	70	73				
										25–76 Sandstone and claystone						
MacPhail	720825	483180	5118700	52	45		18	10	15	0–12 Clay						
										12–52 Sandstone and claystone						
W. MacDonald	710906	483200	5118894	65	45	22	21	7	10	0–17 Clay	60	69				

Name	Date	East. (m)	North. (m)	Depth (ft)	G.S. Elev. (ft)	S.W.L. (ft)	Casing Length (ft)	Yield (lgpm)	Time (min)	Geology	Aquifers (Water Occurrences)					
										17–65 Sandstone and claystone						
Wendell MacLeod	790704	483200	5118800	66	35	13	30	15	15	0–10 Fractured sandstone						
Emmett Williams	790614	483200	5118060	77	35	18	29	8	15	10–65 Sandstone, some claystone 0–20 Sand till	40	43	70	73		
Armand Taylor	790621	483200	5118100	67	80	15	41	15	10	20–77 Sandstone and claystone 0–28 Till	62	65				
Hurry Enterprises	870424	483200	5118000	105	75	36	56	8	7	28–67 Sandstone and claystone 0–30 Till, silt	65	70	95	100		
George Lauther	741008	483200	5118200	106	80	35	53	15	10	20–105 Sandstone, some claystone 0–6 Till						
Norman MacMillan	800913	483200	5118400	100	80	36	63	10	5	6–105 Sandstone and claystone 0–61 Claystone	65	68	75	78	95	98
Sumner Matheson	840726	483200	5118200	100	70	40	48	8	7	61–105 Sandstone and siltstone 0–6 Till	62	65	95	97		
Rollie Ward	790929	483200	5118000	77	85	37	36	6	5	0–100 Layered sandstone and claystone 0–23 Till	37	39	95	99		
Rollie Ward	790914	483000	5118700	96	60	36	33	6	5	23–77 Sandstone and claystone 0–22 Clay till	92	95	74	78		
Rollie Ward	790913	482900	5118900	96	70	36	32	9	5	22–96 Sandstone and claystone 0–27 Claystone	61	64	73	77		
Mervin MacDonald	781220	483200	5120000	90	80	40	31	6	10	27–96 Sandstone and claystone 0–14 Till	40	45	82	86		
W. MacLeod	720226	483201	5118804	67	40	14	21	8	15	14–90 Sandstone, some claystone 0–3 Clay	28	83				
David MacPhail	740709	483203	5118804	70	25	20	34	15	10	3–67 Sandstone 0–30 Clay till	65	68				
Armand Taylor	750817	483204	5118804	70	80	18	28	15	10	30–70 Sandstone and claystone 0–24 Till	65	68				
Bleyce MacRae	630921	483250	5118250	130	80	30	101	8	7	24–70 Sandstone 0–6 Till	120	123				
Cornwall Esso	841031	483250	5119400	140	80	80	104	20	10	6–130 Sandstone and claystone 0–3 Till	120	123	130	133		
Norman MacMillan	841030	483250	5118080	100	80	35	63	8	7	3–140 Layered sandstone and claystone 0–6 Till	65	71	90	93		

Name	Date	East. (m)	North. (m)	Depth (ft)	G.S. Elev. (ft)	S.W.L. (ft)	Casing Length (ft)	Yield (lgpm)	Time (min)	Geology	Aquifers (Water Occurrences)
										6–100 Layered sandstone and claystone	
Bloyce MacPhail	630422	483250	5118800	95	75	35	56	5	7	0–7 Till	86 91
										7–95 Layered sandstone and claystone	
W. MacDonald	710906	483299	5118894	61	45	27	32	7	10	0–28 Clayey sand till	45 56
										28–61 Claystone and sandstone	
F. Gallant	720719	483299	5118894	70	30	14	21	9	8	0–18 Clay	60 70
										18–70 Sandstone	
Mervin MacDonald	760817	483299	5118892	80	70	3[illegible]	22	8	15	0–7 Clay till	35 40 70 75
										7–80 Sandstone, some claystone	
Wendell MacDonald	741010	483300	5118793	80	20	12	24	8	15	0–16 Clay till	36 42 70 73
										16–80 Sandstone	
Armand Taylor	770823	483300	5118800	102	50	27	39	10	7	0–36 Clay till	43 49 81 84 93 96
										36–102 Sandstone, some claystone	
Joe Perry	820525	483300	5119300	120	20	22	55	8	7	0–4 Till	90 98 112 116
										4–120 Sandstone, some claystone layers	
George Lowther	660612	483300	5119300	83	50	28	35	10	10	0–13 Clay, claystone	42 46 61 65 70 83
										13–83 Sandstone, some claystone	
Mervin MacDonald	781111	483300	5119500	84	100	30	22	8	10	0–16 Sand till	48 59 70 75
										16–84 Sandstone, some claystone	
Wendell MacDonald	780525	483300	5119500	108	60	31	40	10	8	0–36 Clay till	49 47 74 77 89 92
										36–108 Sandstone and claystone	
Wendell MacDonald	780512	483300	5119500	101	60	32	42	10	8	0–40 Clay till	46 51 89 96
										40–101 Sandstone and claystone	
Wendell MacDonald	780518	483300	5119500	96	60	99	40	10	9	0–37 Clay till	46 46 74 77 82 86
										37–96 Sandstone	
Wendell MacDonald	780526	483300	5119500	101	75	39	41	10	8	0–39 Clay till	44 47 79 73 84 87
										39–101 Sandstone and claystone	
Wendell MacDonald	780526	483300	5119500	104	75	41	41	10	8	0–39 Clay till	49 49 73 76 87 90
										39–104 Sandstone and claystone	
Wendell MacDonald	780529	483300	5119500	105	75	38	42	10	8	0–40 Clay till	46 49 78 81 89 92
										40–105 Sandstone and claystone	
Wendell MacDonald	780530	483300	5119500	100	60	43	38	10	8	0–34 Clay till	39 42 66 71 88 89
										34–100 Sandstone and claystone	
Wayne Muttart	861020	483300	5119500	78	80	36	49	8	10	0–29 Till, claystone	69 62 71 76

Name	Date	East. (m)	North. (m)	Depth (ft)	G.S. Elev. (ft)	S.W.L. (ft)	Casing Length (ft)	Yield (igpm)	Time (min)	Geology	Aquifers (Water Occurrences)			
										20–76 Sandstone				
Marvin MacDonald	781216	483300	5119800	80	100	36	29	6	10	0–6 Till	46	46	82	86
										6–80 Sandstone, some claystone				
Wendell MacDonald	780806	483200	5119800	86	75	32	36	10	8	0–30 Clay till	46	49	81	84
										30–86 Sandstone and claystone				
Rollie Ward	781116	483300	5119800	80	80	39	31	6	6	0–22 Till	38	41	66	71
										22–80 Layered sandstone and claystone				
Marvin MacDonald	781111	483300	5119800	86	86	40	31	6	10	0–12 Till	46	46	76	80
										12–86 Sandstone, some claystone				
Ernest Stewart	840629	483300	5120800	100	80	16	84	16	10	0–6 Till	80	86	89	84
										6–100 Layered sandstone and claystone				
Herbert Scott	781199	483300	5120819	79	80	16	40	6	10	0–12 Till	42	44	76	79
										12–79 Sandstone, some claystone				
Wendell MacDonald	780102	483500	5120800	86	79	23	46	10	10	0–86 Sandstone, some claystone	86	83	79	79
B. MacPhail	729818	483801	5119804	79	79	36	31	16	6	0–16 Clay till	66	66		
										16–79 Sandstone, some claystone				
Wayne MacRae	719866	483200	5119400	71	46	22	36	16	10	0–16 Clay	66	66		
										16–71 Sandstone and claystone				
George Lowther	751222	483300	5119100	80	36	30	36	16	10	0–6 Till	70	73		
										6–80 Sandstone and claystone				
David MacPhail	740724	483200	5119304	75	46	36	39	16	10	0–36 Clay till	66	66		
										36–75 Sandstone and claystone				
Marvin MacDonald	780630	483300	5119804	79	79	39	32	9	7	0–4 Clay till	46	46	72	76
										4–79 Sandstone, some claystone				
Cornwall School	820720	483400	5119010	80	36	10	21	16	6					
George Lowther	790710	483400	5119100	86	76	27	44	16	6	0–41 Clay till	72	76	87	90
										41–86 Sandstone				
Gary Cummings	790717	483400	5119800	100	36	36	44	7	6	0–100 Sandstone, some claystone	86	91		
Terry MacDonald	860607	483400	5119800	86	80	16	43	10	6	0–6 Topsoil	46	46	66	66
										6–86 Sandstone and claystone				
Serge Valade	850212	483400	5119280	130	36	27	106	6	7	0–4 Till	112	116	126	123

Name	Date	East. (m)	North. (m)	Depth (ft)	G.S. Elev. (ft)	S.W.L. (ft)	Casing Length (ft)	Yield (igpm)	Time (min)	Geology	Aquifers (Water Occurrences)
										4–130 Layered sandstone and claystone	98 104
Eleanor Willis (oil to 83')	851219	483400	5119250	110	80	30	93	10	7	0–3 Till 3–110 Sandstone and claystone	
Wendell MacDonald	780608	483400	5119500	105	75	37	43	10	8	0–41 Clay till 41–105 Sandstone and claystone	86 86 90 93
Wendell MacDonald	780607	483400	5119600	104	75	35	40	10	8	0–37 Clay till 37–104 Sandstone and claystone	80 83 87 90
George Lowther	870416	483400	5119700	73	75	25	42	8	10	0–15 Till, clay 15–73 Sandstone, some claystone	61 63 65 73
Wendell MacDonald	800711	483400	5119800	100	80	35	44	75	1	0–14 Till 14–100 Sandstone and claystone	82 86 86 88
John Wilson	810902	483400	5119900	110	80	40	86	10	15	0–16 Claystone 16–110 Layered sandstone and claystone	70 73 86 88
W. MacDonald		483400	5119603	70	82	31	19	8	7	0–17 Clay 17–70 Sandstone	60 70
Charles Duncan	770912	483400	5119900	82	80	40	38	5	8	0–20 Till 20–82 Sandstone, some claystone	48 51 70 73
D. Mac Construction	790611	483400	5119950	100	85		42	15	30	0–20 Clay 20–100 Sandstone and claystone	42 46
D. Mac Construction	790611	483400	5119990	100	80		44	15	30	0–20 Clay 20–100 Sandstone and claystone	48 46
Wendell MacDonald	771108	483400	5120300	82	86	24	41	10	7	0–37 Clay till 37–82 Sandstone and claystone	69 82 71 74
Winston Taylor	770728	483400	5121200	71	80	24	33	10	8	0–27 Clay till 27–71 Sandstone and claystone	38 41 46 49 66 62
David MacPhail	730910	483403	5119193	70	25	30	30	15	10	0–70 Sandstone, some claystone	60 63
W. MacLeod	720922	483403	5119193	75	30	35	11	8	8	0–11 Clay 11–75 Sandstone and claystone	80 70
David MacPhail	730911	483403	5119293	82	80	19	24	15	10	0–21 Clay till 21–82 Sandstone, some claystone	75 78
D. Mac Construction	790613	483420	5119850	80	80		42	15	30	0–20 Clay 20–80 Sandstone, some claystone	42 46
D. Mac Construction	790611	483420	5119990	80	80		41	15	30	0–20 Clay	41 43

Name	Date	East. (m)	North. (m)	Depth (ft)	G.S. Elev. (ft)	S.W.L. (ft)	Casing Length (ft)	Yield (igpm)	Time (min)	Geology	Aquifers (Water Occurrences)			
										20–80 Sandstone, some claystone				
D Mac Construction	790811	483440	5119890	80	60	-	42	15	20	0–20 Clay	42	48		
										20–80 Sandstone, some claystone				
Jim Burns	790423	483480	5119880	70	25	25	47	15	30	0–8 Till	47	50	60	70
										8–70 Sandstone and claystone				
George Lowther	790713	483480	5119100	92	75	20	44	10	5	0–40 Clay till	67	70	84	87
										40–92 Sandstone				
Bloyce MacPhail	830419	483480	5119000	90	80	25	81	5	7	0–5 Till	86	89	84	87
										5–90 Sandstone, some claystone layers				
Norman MacMillan	880106	483480	5119880	90	80	20	81	5	7	0–4 Till	85	88	84	87
										4–90 Sandstone, some claystone				
Philip Gallant	870858	483480	5119880	90	80	25	87	5	7	0–14 Till, silt	89	93	79	73
										14–90 Sandstone, some claystone				
D. Mac Construction	790812	483480	5119080	80	60		44	15	20	0–20 Clay	44	47		
										20–80 Sandstone, some claystone				
Hilliard Muttart	790823	483600	5119100	95	25	22	40	10	5	0–38 Clay till	88	89	82	85
										38–95 Sandstone and claystone				
Willis MacDonald	800620	483800	5119300	67	20	10	31	5	10	0–9 Till	35	40	60	63
										9–67 Sandstone, some claystone				
Bloyce MacPhail	790727	483600	5119600	95	75	24	37	10	5	0–35 Clay till	46	49	75	78
										35–95 Sandstone				
Mervin MacDonald	790713	483600	5119500	101	75	27	44	15	10	0–41 Clay till	82	86	90	93
										41–101 Sandstone, some claystone				
Wendell MacDonald	801115	483800	5119000	90	80	20	88	60	1	0–14 Till	74	77		
										14–90 Sandstone and claystone				
Wendell MacDonald	801115	483800	5119500	90	80	20	88	60	1	0–12 Till	75	78		
										12–90 Sandstone and claystone				
Wendell MacDonald	801117	483800	5119500	90	80	20	88	60	1	0–11 Till	75	78		
										11–90 Sandstone and claystone				
Wendell MacDonald	801031	483800	5119500	90	80	20	88	60	1	0–10 Till	73	76		
										10–90 Sandstone, some claystone				
Danny Gass	740806	483800	5119500	81	40	25	35	5	15	0–3 Clay till	37	40	74	76
										3–81 Sandstone				
Kent Lennon	841102	483800	5119000	90	80	25	80	15	10	0–15 Till	85	80	79	75

Name	Date	East. (m)	North. (m)	Depth (ft)	G.S. Elev. (ft)	S.W.L. (ft)	Casing Length (ft)	Yield (igpm)	Time (min)	Geology	Aquifers (Water Occurrences)
										15–80 Sandstone and claystone	
Prebuilt Structures	881217	483500	5119600	85	75	36	44	8	10	0–25 Till, claystone 25–85 Sandstone, some claystone	80 83 86 70 90 86
C. Christian Church	881029	483500	5119800	104	80	40	82	8	7	0–8 Till 8–104 Sandstone, some claystone	70 73 86 88
D. Mac Construction	790813	483600	5119880	80	80		43	15	30	0–20 Clay 20–80 Sandstone and claystone	46 46
D. Mac Construction	780920	483500	5119900	100	50	45	36	15	30	0–20 Clay 20–100 Sandstone and claystone	46 46 80 83 86 88
D. Mac Construction	790812	483500	5119910	80	50		46	15	30	0–20 Clay 20–80 Sandstone and claystone	46 46
D. Mac Construction	780920	483500	5119920	100	50	47	36	15	30	0–20 Clay 20–100 Sandstone and claystone	
D. Mac Construction	790812	483500	5119950	80	50		43	15	30	0–20 Clay 20–80 Sandstone and claystone	46 46
D. Mac Construction	780920	483500	5119950	100		44	36	15	30	0–20 Clay 20–100 Sandstone and claystone	
D. Mac Construction	790812	483500	5119970	80	50		43	15	30	0–20 Clay 20–80 Sandstone and claystone	46 46
D. Mac Construction	780920	483500	5119980	100	50	43	37	15	30	0–20 Clay 20–100 Sandstone and claystone	
D. Mac Construction	780921	483500	5120000	100	50	41	37	15	30	0–20 Clay 20–100 Sandstone and claystone	
D. Mac Construction	780921	483500	5120030	100	50	40	37	15	30	0–20 Clay 20–100 Sandstone, some claystone	
Blair MacPhail	770525	483500	5120800	84	80	12	24	10	8	0–23 Clay till 23–84 Sandstone and claystone	84 87 80 88
Bert Caron	790713	483500	5120900	85	100	24	44	10	10	0–41 Clay till 41–85 Sandstone	78 81
Winston Tompson	740424	483504	5119294	87	40	14	47	6	15	0–87 Sandstone, some claystone	82 84 86 83
D. Mac Construction	780922	483540	5119980	100	50	40	38	15	30	0–20 Clay 20–100 Sandstone and claystone	
D. Mac Construction	780922	483540	5120000	80	50	37	37	15	30	0–20 Clay	

Name	Date	East. (m)	North. (m)	Depth (ft)	G.S. Elev. (ft)	S.W.L. (ft)	Casing Length (ft)	Yield (igpm)	Time (min)	Geology	Aquifers (Water Occurrences)
										20–80 Sandstone and claystone	
D. Mac Construction	790921	483640	5120020	80	80	37	37	15	20	0–20 Clay	
										20–80 Sandstone, some claystone	
D. Mac Construction	800921	483640	5120080	100	80	40	38	15	20	0–30 Clay	
										30–100 Sandstone and claystone	
Marvin MacDonald	770715	483800	5119400	70	80	30	31	5	10	0–12 Clay till	40 45 60 65
										12–70 Sandstone, some claystone	
Marvin MacDonald	790714	483800	5119800	105	75	32	44	15	10	0–42 Clay till	60 72 97 100
										42–105 Sandstone	
Wendell MacDonald	770627	483800	5119800	80	75	30	34	10	8	0–33 Clay till	35 38 45 48 64 67
										33–80 Sandstone	
Bagnall Mills Ltd.	770815	483800	5119800	60	80	15	33	15	8	0–60 Sandstone and claystone	40 43 51 56
Gordon Herman	770815	483800	5119800	72	80	15	35	5	15	0–10 Till	45 50 62 66
										10–72 Sandstone and claystone	
George Lowther	751520	483800	5119800	92	75	32	40	10	8	0–37 Clay till	67 70 79 82
										37–92 Sandstone	
Hilliard Mullert	830613	483800	5119800	82	80	40	39			0–23 Till	60 70 75 82
										23–82 Sandstone and claystone	
Fenno DeWise	960613	483800	5120080	80	80	30	33	10	8	0–45 Till and silt	61 64 64 67
										45–80 Sandstone, some claystone	
Billy Clair	790829	483800	5120100	74	35	33	34	15	10	0–6 Sand till	35 40 65 70
										0–74 Sandstone and claystone	
George Lowther	800707	483800	5120400	86	75	46	43	10	8	0–40 Clay till	58 61
										40–86 Sandstone	
Bleyne MacPhail	770615	483700	5120700	81	75	10	25	10	8	0–23 Clay till	32 35 62 66
										23–81 Sandstone	
Bleyne MacPhail	770729	483800	5120800	84	75	13	29	10	8	0–28 Clay till	64 67
										28–84 Sandstone, some claystone	
R. Ward	730130	483801	5119383	72	80	19	42	8	15	0–8 Clay till	65 67
										3–72 Sandstone, some claystone	
Willard MacLeod	780529	483802	5118293	112	75	32	37	10	8	0–34 Clay till	46 49 94 97
										34–112 Sandstone, some claystone	
George Lowther	780429	483802	5119798	60	80	15	36	10	10	0–4 Till	48 51

Name	Date	East. (m)	North. (m)	Depth (ft)	G.S. Elev. (ft)	S.W.L. (ft)	Casing Length (ft)	Yield (igpm)	Time (min)	Geology	Aquifers (Water Occurrences)
										4–60 Sandstone and claystone	
George Lowther	750722	483602	5119844	75	90	20	42	15	10	0–3 Clay till	58 68
										3–75 Sandstone and claystone	
Blair Beers	760624	483650	5119550	80	28	33	33	8	8	0–18 Till	53 58
										18–80 Sandstone and claystone	
Gary Cummings	780918	483650	5119600	110	38	35	30	7	8	0–2 Till	90 98 104 107
										2–110 Sandstone, some claystone	
W. MacLeod	730129	483690	5119386	70	75	23	42	8	15	0–6 Clay	90 98
										6–70 Sandstone and claystone	
David MacPhail	770831	483700	5118200	88	78	14	32	10	9	0–30 Clay till	48 48 84 87
										30–88 Sandstone and claystone	
Wendell MacDonald	770923	483700	5119400	82	28	28	35	8	15	0–8 Till	48 48 72 77
										8–82 Sandstone, some claystone	
Blair MacPhail	780814	483700	5119600	78	100	22	42	10	8	0–30 Clay till	48 51 67 70
										30–78 Sandstone	
Mark MacQuaid	880822	483700	5119800	80	80	19	30	8	10	0–20 Till, sand and clay	38 40 43 48 85 90
										20–80 Sandstone, some claystone	
Blair MacPhail	781123	483700	5119700	93	80	30	55	10	8	0–33 Clay till	41 44 78 78 82 88
										33–93 Sandstone	
Bloyce MacPhail	780928	483700	5119750	110	78	42	40	10	10	0–37 Clay till	48 48 102 104
										37–110 Sandstone	
David Beers	881103	483700	5120100	100	75	80	43	10	10	0–28 Till, sandstone	88 90 85 88 96 100
										28–100 Sandstone, some claystone	
David McQuaid	830830	483700	5120400	127	75	90	90	10	30	0–28 Till	90 90 118 130
										28–127 Sandstone, some claystone	
Bloyce MacPhail	771101	483700	5120900	97	75	14	34	10	7	0–30 Clay till	80 83 98 98
										30–97 Sandstone and claystone	
Blair MacPhail	780804	483750	5119500	78	25	20	40	10	8	0–38 Clay till	48 48 69 73
										38–78 Sandstone	
Blair Beers	780930	483750	5119750	85	30	40	34	8	8	0–20 Till	40 43 73 77
										20–85 Sandstone and claystone	
R. C. Church	791204	483750	5119800	125	80	40	41	10	12	0–38 Clay till	73 78 117 120
										38–125 Sandstone	
Vernon Morrison	791221	483780	5120140	92	85	29	42	10	8	0–38 Clay till	84 87 88 88

Name	Date	East. (m)	North. (m)	Depth (ft)	G.S. Elev. (ft)	S.W.L. (ft)	Casing Length (ft)	Yield (igpm)	Time (min)	Geology	Aquifers (Water Occurrences)
										38-92 Sandstone	
Percy MacKenzie	791208	483770	5120140	96	84	30	40	10	5	0-36 Clay till 36-96 Sandstone	66 71 38 91
Bruce MacLeod	800806	483900	5118300	96	80	28	40	46	3	0-14 Till 14-96 Sandstone, some claystone	90 96 87 90
Marvin MacDonald	790807	483900	5118800	75	80	35	36	15	10	0-8 Sand till 8-75 Sandstone and claystone	36 40 80 70
Marvin MacDonald	790914	483900	5118800	106	75	33	37	20	10	0-13 Sand till 13-106 Sandstone, some claystone	40 80 80 100
Gary Cummings	780120	483900	5118800	100	80	28	43	7	7	0-100 Sandstone, some claystone	88 88 80 98
Bruce MacLeod	821128	483900	5120800	96	75	30	46	8	7	0-8 Till 8-96 Sandstone and claystone	46 82 87 90
Prebuilt Structures	830914	483900	5120400	120	75	44	48	15	10	0-11 Sand till 11-120 Sandstone, some claystone	80 86 85 90 110 115
Prebuilt Structures	830914	483900	5120400	120	75	44	44	15	10	0-11 Sand till 11-120 Sandstone and claystone	80 80 86 90 110 115
Jim Beers	741018	483901	5120300	80	75	48	46	10	10	0-40 Clay till 40-80 Sandstone and claystone	
Keith MacKenzie	880825	483900	5119400	75	75	35	42	8	10	0-10 Till, shale, sand 10-75 Sandstone, some claystone	46 80 83 86 74 78
Marvin MacDonald	790917	483900	5118800	75	75	34	28	7	10	0-8 Sand till 8-75 Sandstone, some claystone	36 40 80 70
Wendell MacDonald	771104	483900	5121200	102	75	32	36	10	7	0-36 Clay till 36-102 Sandstone and claystone	38 42 81 84 82 85
Marvin MacDonald	740417	483902	5120293	96	75	33	30	8	15	0-96 Sandstone	80 84 76 83
Lee MacDonald	740829	483903	5120383	106	88	48	36	15	10	0-4 Till 4-106 Sandstone and claystone	80 88
Wendell MacDonald	800711	484000	5120000	100	75	30	44	75	1	0-11 Till 11-100 Sandstone, some claystone	80 83 80 85
Prebuilt Structures	830914	484000	5120300	90	75	37	44	8	10	0-10 Sand till 10-90 Sandstone, some claystone	85 80 75 86
Prebuilt Structures	830914	484000	5120300	90	75	37	43	6	10	0-11 Sand till	85 80 75 86

Name	Date	East. (m)	North. (m)	Depth (ft)	G.S. Elev. (ft)	S.W.L. (ft)	Casing Length (ft)	Yield (igpm)	Time (min)	Geology	Aquifers (Water Occurrences)
										11–90 Sandstone, some claystone	
Kenneth Craspy	851009	484100	5120200	97	75	30	36	8	10	0–14 Sandy till	88 90 86 86
George Lowther	870512	484100	5120200	90	75	25	30	8	10	14–97 Sandstone, some claystone 0–25 Claystone	86 90 73 76 77 80
Prebuilt Structures	831008	484100	5120400	120	75	58	43	10	10	25–90 Sandstone and claystone 0–10 Sand till	70 90 110 115
Prebuilt Structures	831008	484100	5120400	120	75	23	42	10	10	10–120 Sandstone, some claystone 0–10 Sand till	70 90 110 115
Mervin MacDonald	770503	484100	5120500	85	80	30	31	8	15	10–120 Sandstone, some claystone 0–12 Clay till	48 80 72 75
Parker Beers	750707	484101	5120480	75	85	35	33	15	10	12–85 Sandstone, some claystone 0–30 Till	70 73
Wendell MacDonald	801107	484200	5120300	100	75	25	44	75	1	30–75 Sandstone and claystone 0–15 Till	48 81 88 86
Eldon Clark	820621	484200	5120680	105	100		99	8	7	15–100 Sandstone and claystone 0–6 Till	88 71 94 97
Jack MacMillan	750917	484300	5118800	120	100	90	36	15	10	8–103 Sandstone, some claystone 0–21 Till	110 113
Larry Dumville	710818	484400	5119100	105	100	61	41	8	5	21–120 Sandstone and claystone 0–15 Sand till	48 80 70 75 95 100
Paul Cudmore	810809	484400	5119200	180	110	75	80	7	8	15–105 Sandstone and claystone 0–4 Till	118 118 148 151
Island Tel	800909	484400	5119800	120	88	50	40	80	1	4–180 Sandstone and claystone 0–14 Till	87 90 118 119
Jay Arley	801016	484450	5119000	150	100	75	58	7	8	14–120 Sandstone and claystone 0–6 Till	98 99 142 146
Jay Arley	801008	484450	5119250	150	100	75	66	7	8	6–150 Sandstone, some claystone 0–7 Till	98 98 138 139
Gordon Beck	801218	484450	5119400	180	100	80	65	8	7	7–180 Sandstone and claystone 0–6 Till	108 111 152 155
Allan Simpson	790517	484500	5119300	140	115	50	80	15	15	6–160 Sandstone and claystone 0–6 Till	85 88 128 131
David MacPhail	780629	484500	5119500	122	100	67	40	10	8	6–140 Claystone, some sandstone 0–32 Clay till	98 99 108 111

Name	Date	East. (m)	North. (m)	Depth (ft)	G.S. Elev. (ft)	S.W.L. (ft)	Casing Length (ft)	Yield (igpm)	Time (min)	Geology	Aquifers (Water Occurrences)
										32–122 Sandstone and claystone	
Allan Simpson	700610	484503	5119404	138	100	66	40	10	5	0–24 Till 24–138 Sandstone, siltstone and claystone	90 80 128 131
L. Marney	721003	484803	5119804	160	100	66	42	15		0–20 Clay 20–160 Sandstone and claystone	146 146
Barry Wills	670904	484850	5119800	180	80	53		20	120	0–16 Clay and sand 16–180 Sandstone	80 70 125 130 170 180
Leith MacGowan	790702	484850	5119100	132	100	73	41	10	5	0–56 Clay till 56–132 Sandstone	102 106 121 124
Allan Simpson	790620	484800	5119400	140	110	66	60	15	15	0–10 Till 10–140 Claystone, some sandstone	80 63 110 121 130 138
William Stewart	810822	484800	5119400	162	120	75	60	10	10	0–6 Till 6–162 Sandstone and claystone	80 81 132 136 161 164
Allan Simpson	770827	484850	5119800	155	100	60	44	5	5	0–10 Till 10–155 Sandstone, some claystone	66 66 110 113
Blair MacPhail	790627	484800	5119804	112	36	17	36	10	5	0–21 Clay till 21–112 Claystone and sandstone	67 60 96 96
Robert MacRae	790804	484850	5119800	136	110	70	66	10	5		
Louis Cormier	660617	484700	5119000	130	100	70	48	10	10	0–10 Sand and clay 10–130 Sandstone, some claystone	82 84 90 94 125 130
Robert Corrigan	660600	484700	5119200	121	100	70	52	10	10	0–24 Clayey till, clay and sandstone 24–121 Sandstone, some claystone	75 90 105 118
John Hanslow	820002	484700	5119800	140	100	70	64	20	10	0–20 Claystone 20–140 Claystone, some sandstone	80 85 110 118 125 130
Don Campbell	660606	484700	5119400	128	100	66	64	10	10	0–24 Clayey till, sandstone and clay 24–128 Sandstone, some claystone	70 80 115 125
Ron Chandler	670710	484800	5119100	131	100	72	57	5	10	0–30 Till, claystone 30–131 Sandstone, some claystone	80 66 100 110 121 131
Allan Simpson	770629	484850	5119300	127	90	60	44	5	5	0–20 Till 20–127 Sandstone and claystone	80 83 112 118
Charles MacLennan	790618	484801	5119200	142	100	74	61	5	3	0–18 Clay till 18–142 Sandstone and claystone	80 86 136 142
T. Jones	711007	484803	5119000	135	85	67	36	5	15	0–30 Clay	84 110

Name	Date	East. (m)	North. (m)	Depth (ft)	G.S. Elev. (ft)	S.W.L. (ft)	Casing Length (ft)	Yield (lgpm)	Time (min)	Geology	Aquifers (Water Occurrences)
										30–125 Sandstone	
Arthur Perry	800808	484850	5119450	140	100	50	60	10	10	0–16 Till and silt	80 83 130 133
										16–140 Sandstone, some claystone	
Allan Simpson	780906	484900	5119400	142	80	40	41	7	5	0–25 Clay	72 76 139 133
										25–142 Sandstone and claystone	
Harold Donahue	770712	484900	5120400	129	80	84	25	9	5	0–24 Clay till	86 86 94 97
										24–129 Sandstone and claystone	
Leroy Vessey	720812	484901	5119085	81	100	27	27	15	15	0–23 Clay till	80 83
										23–81 Sandstone	
Holiday Haven	800208	485100	5118400	258	70	47	43			0–6 Till	80 83 90 93 135 139
										6–258 Sandstone and claystone	
Thod Huez	780913	485201	5119082	145	100	75	86	8	10	0–14 Clay till	86 86 135 136
										14–145 Sandstone, some claystone	
		Averages		101		36	43	12			

APPENDIX II

WATER QUALITY DATA

APPENDIX II
Water Quality Analyses
CORNWALL

Name&Date		Easting/Northing	Parameters																	
			Ca	Mg	Na	K	Hard.	Alk.	Cl	SO4	P	NO3	pH	Fe (T)	Fe (D)	Mn	Cd	Cu	Cr	Ni	Pb	Zn
Linda Allen	871102	483500/5119400	19.5	10.77	7.4	2.01	93.2	96	10		0.08	1.4	8.1	< 0.1	< 0.1	< 0.02		< 0.02			< 0.1	< 0.02
Errol Andrews	840504	483400/5119600	41.6	20.10	27.1	2.27	188.6	139	70		0.10	2.5	7.4	< 0.1	< 0.1	< 0.02		0.09			< 0.1	1.18
Zella Beaulac	860210	483400/5119600	24.5	13.70	7.6	2.14	118.0	113	15		0.10	3.3	7.6	2.8	< 0.1	0.11		0.15			< 0.1	< 0.02
Vaugh Blackadar	830623	483800/5119800	35.9	15.32	32.0	1.86	153.0	108	90	7	0.10	3.0	7.2	< 0.1	< 0.1	0.09	< 0.02	0.04	< 0.05	< 0.05	< 0.1	0.27
Brook	860912	482850/5117300	22.4	12.60	9.6	2.05	109.0	119	25	9	0.08	1.5	7.9	< 0.1	< 0.1	< 0.02	< 0.02	< 0.02	< 0.05	< 0.05	< 0.1	0.64
Ross Burgoyne	851127	482900/5118400	14.4	7.26	7.9	1.89	66.3	63	24		0.08	2.8	6.3	< 0.1	< 0.1	0.05		0.19			< 0.1	0.11
Carl Buell	730807		38.0	19.40	25.0	3.90	175.0	146	51	16.7	0.02	1.3	6.9	0.1		0.34	< 0.02	0.03			< 0.1	0.73
Christ. Church	870205	483300/5119500	30.6	11.75	6.9	2.24	125.9	155	14		0.09	3.9	8.3	< 0.1	< 0.1	< 0.02		0.04			< 0.1	0.61
Eldon Clark	830511	484300/5120700	31.1	11.97	7.6	1.19	127.0	99	13	4	0.11	3.0	8.0	< 0.1	< 0.1	< 0.02		< 0.02			< 0.1	1.67
Jim Clark	870708	483100/5118700	28.3	17.35	13.0	1.90	142.3	111	32		0.10	3.2	7.7	< 0.1	< 0.1	< 0.02		< 0.02			< 0.1	< 0.02
Esso	820317	483300/5119400	26.0	14.60	18.0	2.20	125.0	133	40	12	0.04	0.2	7.1	1.1	< 0.1	4.20		0.02			< 0.1	1.02
Harold Gates	861028	27 Kellow Dr.	27.1	13.84	6.5	1.47	125.4	125	14	9	0.10	4.2	7.6	< 0.1	< 0.1	< 0.02	< 0.02	0.10	< 0.05	< 0.05	< 0.1	0.34
Vaughn Horton	861210	39 John St.	15.5	9.20	4.7	2.01	76.8	90	19		0.10	0.7	7.9	< 0.1	< 0.1	< 0.02		0.08			< 0.1	< 0.02
Bob Jay	831107	483400/5119400	41.7	21.63	30.5	2.95	195.1	187	110		0.07	1.4	7.6	< 0.1	< 0.1	0.04		0.07			< 0.1	1.13
Robert Jewell	860325	483008/5119150	44.2	20.99	132.0	2.56	197.9	70	300		0.08	3.2	7.1	< 0.1	< 0.1	< 0.02		0.04			< 0.1	0.58
John Joseph	820203	483400/5119300	49.0	21.30	15.0	2.25	210.0	188	33	9	0.08	0.8	7.6	0.1	< 0.1	0.51		0.08			< 0.1	0.60
Peter Lagrow	830921	484400/5119200	34.7	14.05	8.0	1.10	145.6	121	33	5	0.10	4.6	7.8	< 0.1	< 0.1	0.05		0.02			< 0.1	0.56
J.E.MacCallum	850507	483500/5119300	35.1	18.95	14.7	1.92	166.1	136	40		0.12	1.5	7.5	< 0.1	< 0.1	< 0.02		0.42			< 0.1	0.17
Blois MacPhail	801209	483520/5119800	28.0	10.40	7.0	1.70		97	12	12	0.12	4.0	7.0	0.2	< 0.1	< 0.02		0.12			< 0.1	0.10
Blois MacRae	830926	483250/5119250	34.0	12.20	8.0	2.35	137.0	112	13	2	0.12	1.2	8.4	0.4	< 0.1	< 0.02		0.02			< 0.1	1.09
Jim Molyneaux	860407	482900/5118700	35.8	11.78	8.4	2.18	141.1	87	20		0.06	3.0	7.6	< 0.1	< 0.1	0.03		0.03			< 0.1	1.96
H. Montbourquette	821214	483350/5119400	43.0	17.20	24.4	2.13	178.0	179	50	8	0.10	2.8	8.4	0.3	< 0.1	0.02		0.13			< 0.1	0.19
Carl Murray	870728		46.8	26.31	9.1	1.56	225.5	100	9		0.10	1.7	7.9	< 0.1	< 0.1	0.05		< 0.02			< 0.1	< 0.02
PEI Housing	830711	483300/5119300	30.0	11.93	7.4	1.59	123.0	109	15	3	0.10	2.8	7.4	< 0.1	< 0.1	< 0.02		0.03			< 0.1	0.78
Harold Pineau	770401	482800/5118700	28.0	12.50	10.5	1.40		83	35		0.08	1.2	8.1		< 0.1	< 0.02		< 0.02			< 0.1	0.08
Post Office	860708	483100/5119200	29.4	13.61	5.9	1.69	130.3	77	23		0.11	5.8	7.8	< 0.1	< 0.1	< 0.02		0.04			< 0.1	0.41
Brian Ramsey	870413	483800/5119700	35.6	20.04	23.2	2.93	171.7	150	85		0.09	3.5	7.2	< 0.1	< 0.1	< 0.02		0.05			< 0.1	0.10
Gary Ramsey	870616	483250/5119650	41.2	18.72	7.1	1.81	181.5	127	18		0.08	3.0	7.5	< 0.1	< 0.1	< 0.02		0.04			< 0.1	0.89
Ron Rogers	811028	484500/5119400	55.0	13.00	8.0	1.60	191.0	151	13	15	0.08	0.6	7.0	< 0.1	< 0.1	0.05	< 0.02	< 0.02	< 0.05	< 0.05	< 0.1	0.12
Joost Roggeveen	830301	483500/5119600	23.8	14.93	9.5	1.93	121.0	108	15	7	0.12	4.4	7.5	< 0.1	< 0.1	< 0.02		0.93			< 0.1	0.51
George Rooney	850807	482800/5118700	22.8	12.86	10.1	1.78	110.3	96	23		0.10	2.6	7.5	< 0.1	< 0.1	< 0.02		< 0.02			< 0.1	0.16
John Ross	821209	484500/5119350	34.0	13.00	8.2	1.19	138.0	127	14	7	0.10	< 0.1	8.1	0.2	< 0.1	< 0.02		0.04			< 0.1	0.05

Name&Date		Easting/Northing	Ca	Mg	Na	K	Hard.	Alk.	Cl	SO4	P	NO3	pH	Fe (T)	Fe (D)	Mn	Cd	Cu	Cr	Ni	Pb	Zn
Shell	831129	483100/5119100	20.9	19.01	15.6	2.40	131.0	108	27		0.10	2.3	7.8	< 0.1	< 0.1	< 0.02		< 0.02			< 0.1	0.24
Shell	840822	483100/5119100	31.2	15.85	7.6	2.60	143.7	100	23		0.04	2.5	8.0	< 0.1	< 0.1	0.03		0.05			< 0.1	0.21
Rennie Stanley	850314	483450/5118550	20.3	12.10	5.3	1.66	101.0	102	16		0.06	2.3	7.9	< 0.1	< 0.1	< 0.02		< 0.02			< 0.1	0.20
St. Francis	830221	483750/5119850	19.3	8.34	10.0	2.06	82.0	133	13	5	0.06	4.9	8.1	0.3	< 0.1	< 0.02		0.11			< 0.1	0.21
St. Francis (w)	830324	483750/5119850	28.0	16.19	7.1	1.24	137.0	131	14	4	0.06	9.0	8.0	0.2	< 0.1	0.03		0.75			< 0.1	0.50
St. Francis (k)	830324	483750/5119850	28.8	17.35	7.3	1.24	143.0	152	13	4	0.10	2.7	8.1	< 0.1	< 0.1	0.02		0.06			< 0.1	0.60
John Story	871102	482600/5118500	13.9	8.83	8.1	2.44	71.3	99	17		0.12	2.8	7.8	< 0.1	< 0.1	< 0.02		0.03			< 0.1	< 0.02
Armand Taylor	810720	483520/5119600	31.0	13.90	16.0	2.30	159.0	114	40	10	0.06	3.3	7.5	0.1	< 0.1	< 0.02		0.27			< 0.1	0.25
Henry Trembiett	811028	484600/5119400	36.0	7.20	6.0	1.20	119.0	135	12		0.10	0.8	7.7	< 0.1	< 0.1	< 0.02	< 0.02	< 0.02	< 0.05	< 0.05	< 0.1	0.10
Serge Valade	850212	483300/5119200	22.3	13.32	18.6	2.64	111.1	122	33		0.10	0.6	7.8	< 0.1	< 0.1	< 0.02		0.07			< 0.1	0.25
Barry Willis	870807	484500/5118400	34.6	18.43	6.0	1.42	162.6	106	15		0.16	5.5	7.6	0.2	< 0.1	0.06		< 0.02			< 0.1	< 0.02
Eleanor Willis	850510	483350/5119300	46.5	15.81	120.0	5.89	184.3	119	210		0.10	1.4	6.6	0.2	< 0.1	1.44		0.08			< 0.1	0.18
Sunny King Motel	810803	483230/5119380	40.0	14.80	8.0	1.60	161.0	149	17	11	0.09	3.3	7.8	0.2	< 0.1	< 0.02		0.41			< 0.1	0.65
Sunny King Motel	860807	483230/5119380	35.2	17.13	9.0	1.92	159.4	138	22		0.10	3.0	7.7	< 0.1	< 0.1	< 0.02		0.09			< 0.1	0.49
Holiday Haven 1	780825	485400/5117700	28.0	13.00	14.5	1.90	126.0	98	32		0.14	2.7	7.8	0.1	< 0.1	< 0.02		< 0.02			< 0.1	0.12
Holiday Haven 2	780825	485400/5117700	110.0	25.50	330.0	4.90	586.0	82	700		0.10	4.5	7.7		< 0.1	< 0.02		< 0.02			< 0.1	0.05
Holiday Haven 3	780825	485400/5117700	29.0	17.00	100.0	2.70	145.0	97	170		0.08	0.7	8.0	0.1	< 0.1	< 0.02		< 0.02			< 0.1	0.02
Holiday Haven	810803	485400/5117700	29.0	10.80	10.0	1.80	117.0	101	17	8	0.14	3.0	7.6	0.3	< 0.1	< 0.02		0.20			< 0.1	0.46
Holiday Haven	850730	485400/5117700	44.5	23.60	90.0	1.97	209.1	102	240		0.14	4.1	7.7	< 0.1	< 0.1	0.04		0.05			< 0.1	0.41
Holiday Haven	870812	485400/5117700	30.7	18.65	6.5	1.49	153.6	120	13		0.12	4.3	7.5	< 0.1	< 0.1	< 0.02		< 0.02			< 0.1	< 0.02
Byways Trailer	841017	483300/5119000	23.3	13.72	7.6	1.36	114.9	122	31		0.18	3.2	8.0	< 0.1	< 0.1	< 0.02		< 0.02			< 0.1	< 0.02
Byways Trailer	850410	483300/5119000	33.6	15.13	9.6	1.73	146.6	115	29		0.12	3.3	7.6	< 0.1	< 0.1	< 0.02		0.02			< 0.1	0.12
Byways Trailer	860430	483300/5119000	37.6	17.77	12.9	2.08	169.0	110	32		0.05	3.1	7.6	< 0.1	< 0.1	< 0.02		0.03			< 0.1	1.18
Byways Trailer	870820	483300/5119000	33.3	20.52	11.0	2.04	168.0	116	28		0.08	3.0	7.7	< 0.1	< 0.1	< 0.02		0.05			< 0.1	0.12
Elementary Sch.	850402	483390/5118990	18.3	8.30	5.3	0.99	80.4	116	32		0.09	3.5	7.7	< 0.1	< 0.1	< 0.02		0.06			< 0.1	0.25
E. Riv. Elem. Sch.	850402	482680/5118840	31.1	15.06	8.1	2.37	140.2	127	20		0.11	3.7	7.6	< 0.1	< 0.1	< 0.02		0.09			< 0.1	0.24
Sr. Citizens	850314	483500/5119500	23.8	12.44	6.9	1.66	111.2	122	14		0.10	2.2	7.6	0.2	< 0.1	< 0.02		0.13			< 0.1	0.21
Sr. Cit. (C)	870216	483500/5119500	27.5	10.25	9.8	2.03	111.8	133	20		0.05	2.7	8.1	< 0.1	< 0.1	< 0.02		0.18			< 0.1	0.46
Sr. Cit. (H)	870216	483500/5119500	23.9	9.69	9.6	2.04	99.8	131	20		0.08	2.9	8.0	< 0.1	< 0.1	< 0.02		0.74			< 0.1	0.04
		CDWS							250	500		10.0	6.5-8.	0.3		0.05	0.005	1.00	0.05		0.05	5.00